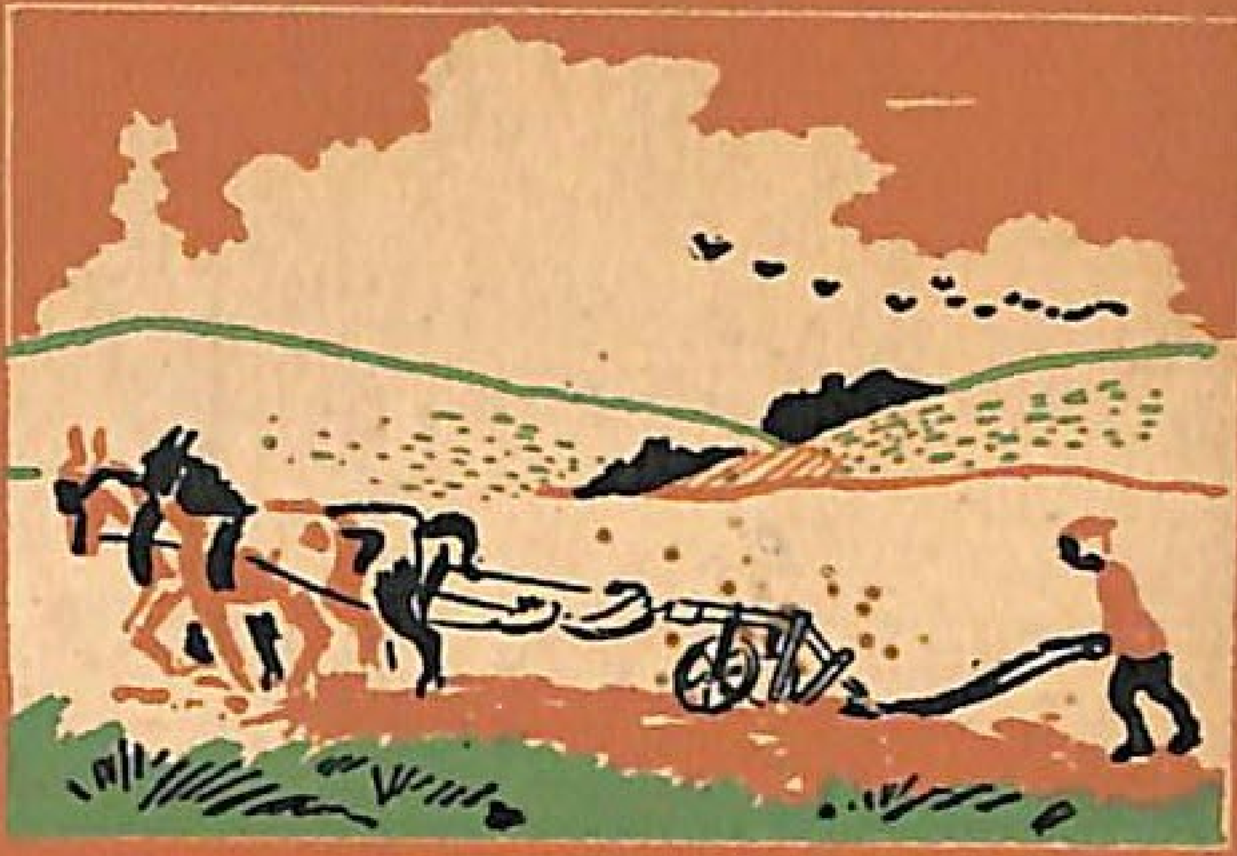

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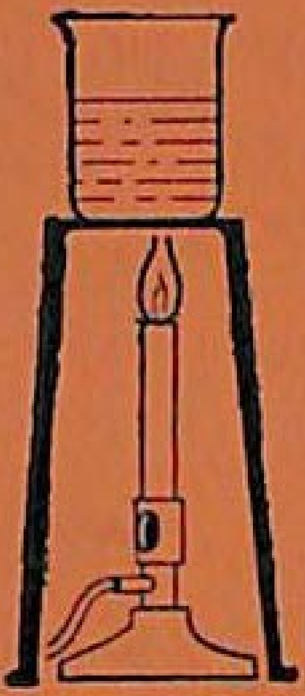

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LIFE
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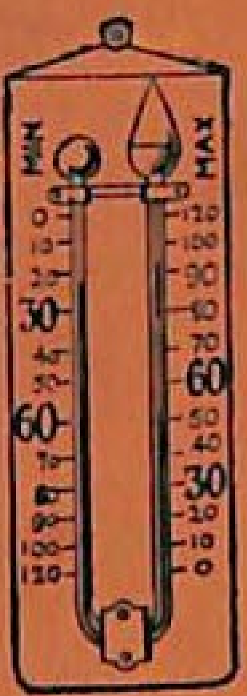

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SCIENCE ON THE MARCH
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UNIT FOUR

LIFE AND FOOD

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The first twelve units of SCIENCE ON THE MARCH:

1. The Air and You.
2. Water and Life.
3. The Weather and the Earth.
4. Life and Food.
5. Health.
6. Energy and Engines.
7. Hearing and Seeing.
8. Electric Currents.
9. Magnets and Electric Power.
10. Earth and Universe.
11. Heating and Cooling.
12. Birth and Growth.

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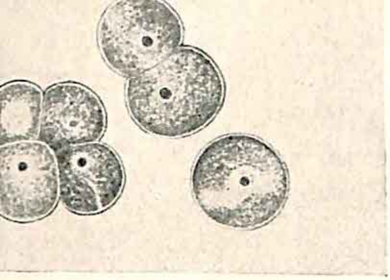
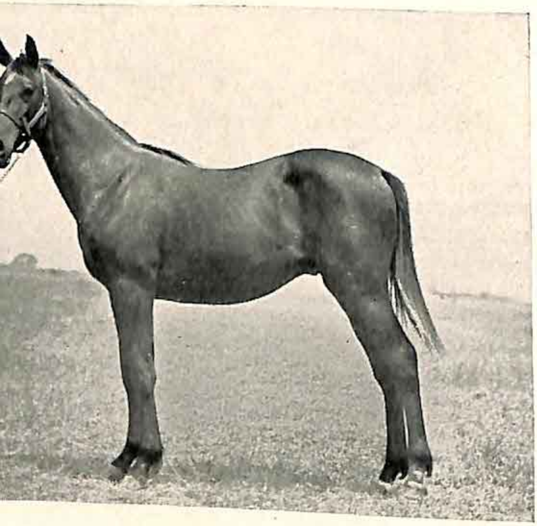


ngle-celled plant dividing into four.

Single-celled animal.



Ewing Galloway, N.Y.

M. Hubbard

FIGURE 1. Is it easy to tell whether all living things are plants or animals?

Jellyfish.

Paul Popper

Fish.

Mirrorpic

Life and Food

Six kinds of living things are shown opposite. Can you point out some ways in which they are similar, and some other ways in which they differ ? Do they live in the same places ? Do they get food in the same way ? Of what use is each to us ?

Man has always been interested in questions like these about plants and animals. Thousands of years ago men could only feed themselves by hunting and fishing and gathering fruits, like other animals. Then primitive man took a giant stride forward by learning to farm, learning how to keep and breed and domesticate certain wild animals, learning how to sow and grow and improve certain wild plants.

Man has still much to learn. In many parts of the world today there is still not enough food to keep everybody strong and healthy. And those of us who live in towns and get our food from the tin, the bottle and the shop, are completely dependent for life on those who spend their lives growing food. Our industries too depend on the farmer all over the world for many of our raw materials, for the jute which we make into sacks, for the rubber we make into tyres, for the timber we make into houses and furniture, for the wool and cotton we make into clothes, for the leather we make into shoes.

To keep Science on the March in the fields as well as in the factories, we must first study plants and animals. In this Unit we shall find out a little about the nature of Life, and a little about the way in which plants and animals behave.

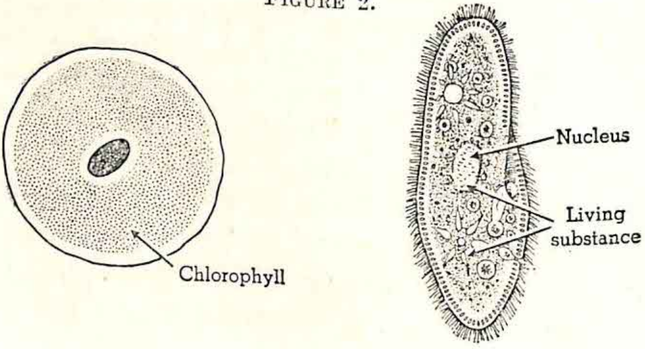
Problem A: **WHAT IS THE NATURE OF LIFE?**

You have no difficulty in deciding that many common living things are either plants or animals. For instance, the tree shown in Figure 1 is plainly a green plant, and the horse is an animal. But how about the top two photographs? Without the labels could you tell which is plant and which is animal? In this case it is not so easy to be certain, because the two are so much alike. Let us begin our study of these matters by learning about some small things that dwell in ponds and streams.

Problem A: What is the nature of Life?

Question 1. **What are Living things?**

Perhaps you have a chart or a film strip which shows some small, rather simple green plants and animals like those in Figure 2. Each is made up of one single *cell* or unit, which has a well-marked outer boundary or wall. Within the cell is the living substance—a mass of material, most of which is fluid. This is the material that makes life possible.



Pleurococcus — a single-celled plant. The black spot in the middle is the nucleus.

Paramecium (the slipper animalcule) —a single-celled animal.

FIGURE 2.

One difference between the green plant cell and the animal cell may be seen at once. This is the presence of small green masses in the plant cell. They are the things that make the cell green in colour, and they contain the substance called *chlorophyll*. This difficult word chlorophyll, like many other scientific words, is a mere label and does not help us to understand anything more about the subject. It has been made up from two Greek words, one of which means *leaf* and the other of which means *green*. By thinking of other words containing *chlor* or *phyll* can you guess which part means green?

In Problem D you will learn why chlorophyll is important, not only to plants, but to men. The chlorophyll does not dye the leaf green, but is gathered round very tiny particles which are called *plastids*. A plastid containing chlorophyll is called a *chloroplast*, i.e. a green plastid.

What is one difference between a green plant and an animal?

How large are the living things that you have just studied?

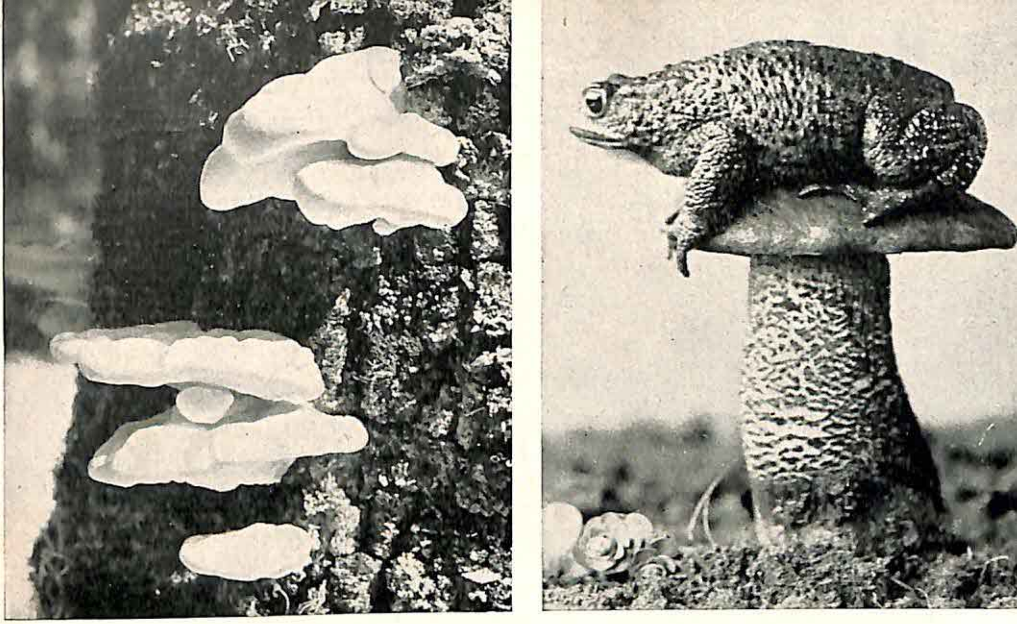
POND LIFE

One of the best places to get acquainted with plants and animals is along the border of a shallow pond. Here we often find that many reeds and other plants grow right down to the water's edge. Then comes the shallow water, with a muddy bottom upon which lie the decaying remains of plants and other things.

Pond scums may be seen upon the surface. They are really green plants. Near the shore you will probably see some small fish and some water snails, and in early summer there will probably be tadpoles. Then you will also find water-dwelling insects such as water-boatmen and water-beetles and the " blood-worm " larvae of the fly Chironomus and the larvae of the Caddis-fly in their tubular houses. And you will probably find the fierce Water-Tiger, which is the larva of the big water-beetle Dytiscus. In mud not too near the edge of the pond you may also discover the large freshwater mussel. These are all animals and they are among the larger things that live in such a place. If you were to look at a drop of pond water through a microscope, you would no doubt see some of the tiny plants and animals like those in Figure 2. Actually, they may be present in great numbers, but most of them are too small to be seen by the unaided eye.

Such a shallow pond and the things that live in it may be called a community. Perhaps you have already learned that green plants use the energy of sunlight to make foods out of water and carbon dioxide. We shall read more about this under Problem D. Thus the plants are able to grow and become more abundant. They serve as food for some of the animals. Other animals eat smaller forms of animal life. Now can you see why we can talk of a pond community ? And also why the comparison is not altogether a good one ?

Another large group of living things also is present in and about the pond, but some of the larger examples may be found on the land. These are the fungi, similar to those shown in Figure 3. They are plants, but they do not contain the green material called chlorophyll, and therefore are unable to make food. For this reason they are sometimes called *dependent plants*. Not all are as large as the ones shown here, and some can be seen only with the aid of a microscope.



Fenton *The Times*

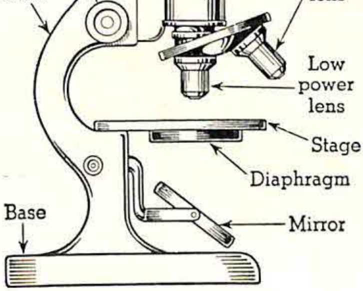
FIGURE 3. Two common types of fungi.

Bracket fungus. Toadstool.

SOME THINGS YOU MAY CARE TO DO

1. With the aid and consent of your teacher, learn to use a compound microscope. The first step is to adjust the mirror (see Figure 4), so that you see an even, white field when looking through the eyepiece. Then place a microscope slide bearing some object on the stage. Turn the coarse adjustment until the lens is close to the slide. Then look through the eyepiece, and turn the fine adjustment so that it is gradually raised

FIGURE 4. A compound microscope.



until the image comes into focus. Practise until you have learned to do these things well.

2. With the aid of a microscope examine materials taken from the waters of a pond or an aquarium. Try to tell the difference between plants and animals. Note the various things that different plants and animals can do.

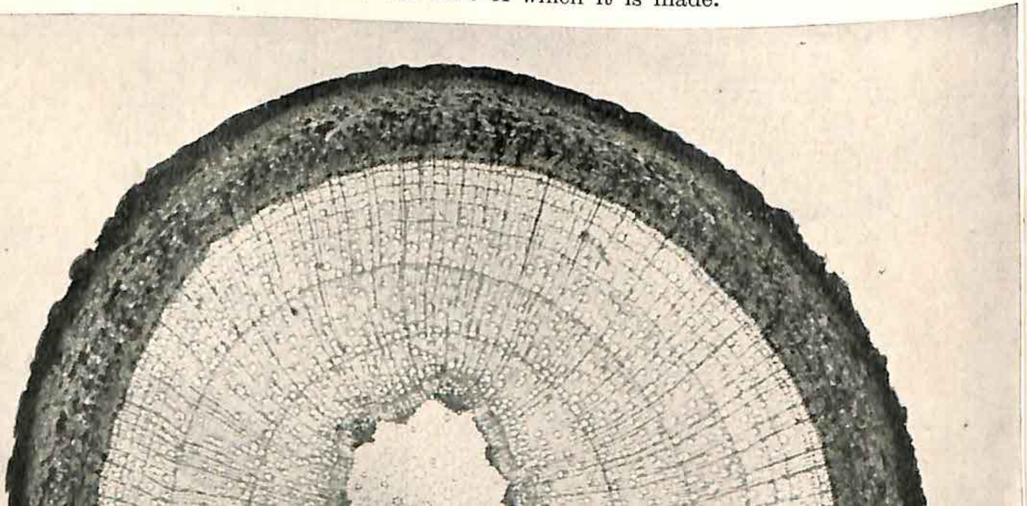
3. Various living things can: (*a*) move parts of their bodies; (*b*) move the entire body; (*c*) use oxygen; (*d*) make food; (*e*) use food; (*f*) grow; (*g*) reproduce; (*h*) excrete wastes. Make a list of five common plants and five common animals, and try to decide which of these abilities is shown by each type.

Problem A: **What is the nature of Life?**

Question 2. **How are Living things Similar?**

You have learned in answering Question 1 that some of the smallest animals and plants consist of just one cell, containing a living substance. Anything that these cells can do is due to such material. Plants and animals—large and small—use energy, discharge wastes, grow, reproduce, and do other things. To this extent they are similar and their living substance must therefore, we suppose, behave in a somewhat similar way and

FIGURE 5. A section of a plant stem, greatly enlarged to show the cells of which it is made.



have somewhat the same nature.

There is another way in which plants and animals are alike. Look at some microscope slides of a section of plant or animal tissue like the one in Figure 5, or at a film strip or charts of such sections. Note the little box-like compartments. They are the units or cells and every one formerly contained the living substance. By such study men have discovered that all living things are built up of cells.

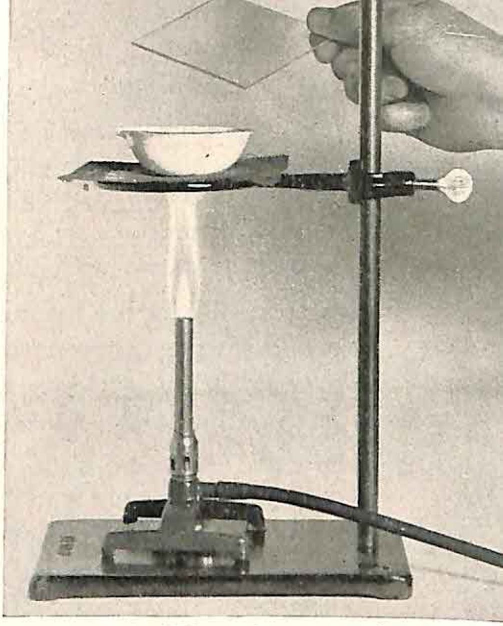


FIGURE 6. When the carrot in the dish is heated, moisture will collect on the glass held above it.

Are all cells the same size and shape?

You can learn more about living material by putting a slice of carrot in a porcelain dish, and heating it over a flame, as shown in Figure 6. Hold a piece of glass just above the dish while the heating is going on. Drops of water will collect on its lower surface. After a time nothing remains in the dish except some charred, black material in the bottom. A chemist will tell you that this is largely carbon.

Might some other things have been present also?

LIVING SUBSTANCE

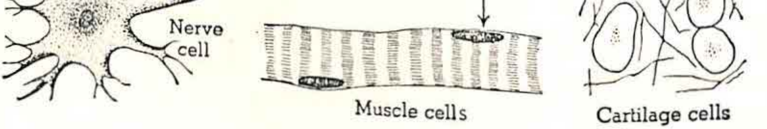
Water is made up of hydrogen and oxygen. The experiment has shown us that the carrot contains hydrogen and oxygen, and also carbon. Actually, other things were also present, among them nitrogen. Hydrogen, oxygen, carbon, and nitrogen make up the bulk of living substance. But other elements are concerned as well, some of them very important though present only in the very minutest traces. Indeed the structure of living material is amazingly complex, and not completely understood.

Scientists have named the living substance *protoplasm*. They have found that in it carbon, hydrogen, oxygen, and nitrogen are combined to form a number of things. One of these is water (hydrogen and oxygen). Others are the well-known food substances such as meats (called *proteins*), fats and vegetable oils (called *fats*), and starches and sugars (called *carbohydrates*). If you had used a piece of meat instead of a carrot in the foregoing experiment, the result would have been similar. But the smell obtained before the final stage was reached would have been different.

Cells. No matter how large or complicated the body of a plant or of an animal may be, it is made up of cells, or of parts that have been formed by cells.

Not all cells, of course, are exactly alike. They differ in size, in shape, and in the things that they can do. Figure 7 shows several different kinds. They do not look the same, but they are all cells.

FIGURE 7. Four types of cells, greatly enlarged. Do you see ways in which they differ ?



Our own bodies are no exception. They are masses of cells—billions of them. Within these tiny units the work of the body goes on. Great numbers of them are active whenever we make even a slight movement. Many cells work all the time, even while we are sleeping.

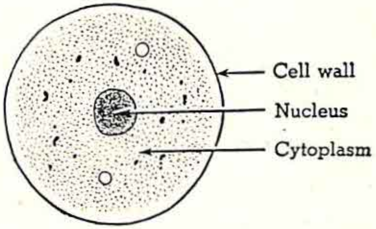


FIGURE 8.

SOME THINGS YOU MAY CARE TO DO

1. Using a razor blade, cut a green plant stem in two. Then, holding the stem vertically between left thumb and forefinger, cut a thin slice directly across one of the cleanly severed ends. Place the slice on a microscope slide, add a drop of water, and cover it with a cover glass. Examine it with the aid of a microscope. What you have is a cross-section of a stem, similar to that shown in Figure 5. Can you find evidence that tissues are made up of cells ?

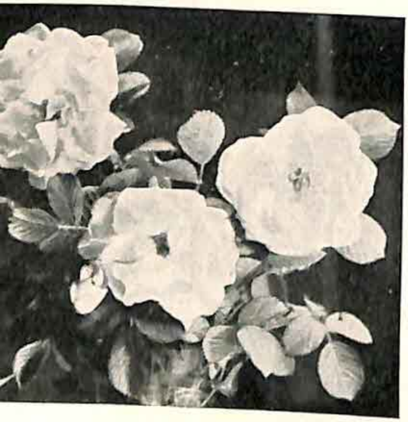
2. Examine a stained cell with the aid of a microscope. Try to locate the parts shown in Figure 8.

3. Take two apples of about the same size. Weigh each carefully and make a record of its weight. Place one of the apples on a hot radiator or similar place, and the other in a cool but frostproof place. Leave them until the apple in the warm place has shrivelled quite small. Then weigh both and find out how much lighter each has become. How can you account for the apple in the warm place losing weight faster than the other ? How can you relate this to what you have learned about living substance ? What explanations can you offer for the loss of weight by the apple which was kept in a cool place ?

Question 3. **How do Living things Differ?**

You have now seen that living things are not only alike in some respects, but unlike in others. To be sure, certain small plants and animals look very much the same, but even in such cases there are differences that can be seen by an expert. For example, you have learned that a green plant contains chlorophyll, but that an animal does not. You know that some plants and animals can be seen only through the lenses of a microscope, but that others are far larger than man. *Can you name some of the biggest plants in the world and say where they are found? And which would you consider the heaviest living animal and which the tallest?*

FIGURE 9. How do these pictures show you ways in which living things differ?



Flower.

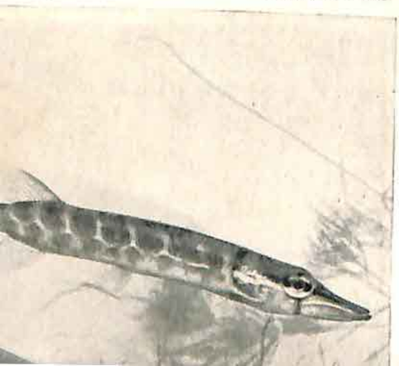
Blackington Service

Bat.

Henry B. Kane

Fish.

Henry B. Kane



Mole.

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Size, of course, is only one of the ways in which living things differ, as we can see when we begin to make comparisons. Many of the larger living things which at first sight look similar actually show striking differences. A field trip will furnish plenty of examples: so will a study of film strips showing various plants and animals. It is not enough merely to *see* that living things vary. You should also be able to tell *how* they differ.

Are all trees or all rabbits or all flies or all earthworms exactly alike?

DIFFERENCES AMONG LIVING THINGS

Figure 9 shows four forms of life. Each of these has parts that makes it quite unlike all the others. Study the pictures carefully and list the things which are peculiar to each of the four. Do all the three animals possess eyes and ears? It is because of the differences that each acts in its own way. The bat is the only one of the four that can fly. Similarly, the plant alone can produce flowers and seeds. Only the fish lives in the water, and only the mole burrows in the soil.

It is because of differences such as these that we are able to separate plants from animals, and one kind of animal or plant from another. Some types are very much alike, to be sure, but in other cases the differences are striking. We depend upon them in recognizing the living things of our world. Most of us, for instance, can name several kinds of dogs, and tell them apart. If we meet a breed of dog we have never seen before, we should probably know it was a dog just the same. Certainly we should not think it was a cat.

It is also worth noting that individual members of the same kind of plant or animal are not quite the same. Some are larger than others. Many do not

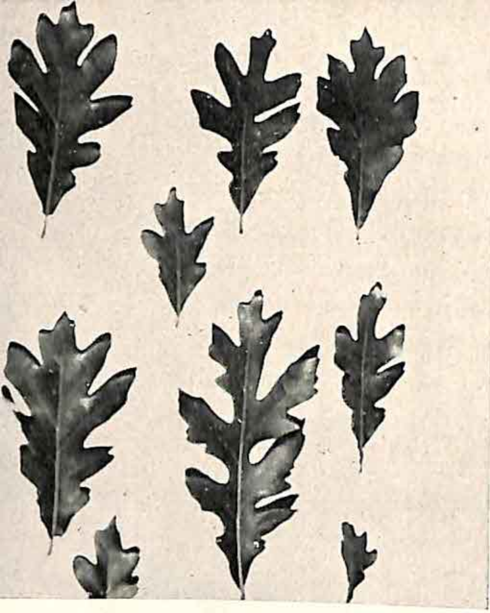


FIGURE 10. Leaves from one tree, showing how they may vary.

have exactly the same form or colour. Even like parts of one individual may vary. The leaves shown in Figure 10 all came from the same tree, but you can see that they are not the same size or shape. A dozen roses blooming in the garden may look alike at first glance, yet careful study shows that they are not.

Let us now combine the two important general things that have been learned in this and the preceding problem. By observing how all living things are alike, and also how they differ, man has been helped to discover how to care for the plants and animals that we want to raise, and how to control the plants and animals that become pests.

SOME THINGS YOU MAY CARE TO DO

1. Prepare an exhibit of leaves taken from different plants, to show how such parts vary.

2. Using your school library prepare a report in which you contrast plants and animals that are very large with others that are very small.

3. Sprout ten broad-bean seeds in a container filled with soil. Water the young plants, and keep them in sunlight. Compare them after two weeks' growth, to see if they are exactly alike.

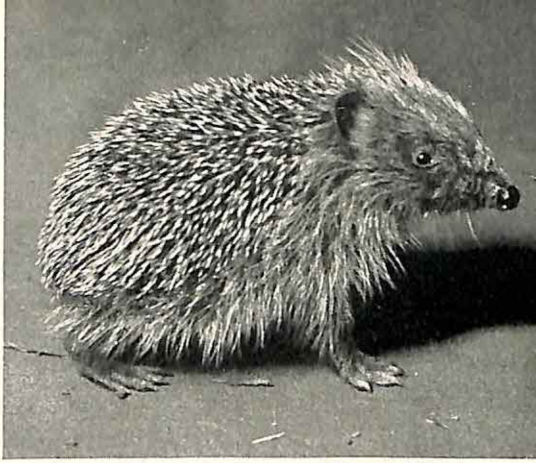
4. Study the plants and animals in an aquarium. Be prepared to say how they differ with respect to: (*a*) size; (*b*) colour; (*c*) food that they use; (*d*) any manner of behaviour.

Problem A: What is the nature of Life?

Question 4. **How do Living things Survive?**

You have learned that plants and animals carry on various life activities. The things that they do, enable them to survive—that is, to keep on living. Some kinds of living things have special structures or parts which help them to obtain food, avoid enemies and other things that they may have to do. Have you ever heard of places in which grasshoppers became so numerous that they ate up the crops? Have you seen gardens that were "smothered" by weeds? Things like this sometimes happen, and they show that some kinds of plants and animals may become very abundant when conditions are favourable. They may thus become pests.

Adaptations. Study the things in Figures 11 and 12. Cactus plants are found in dry, desert-like places,



Frances Pitt

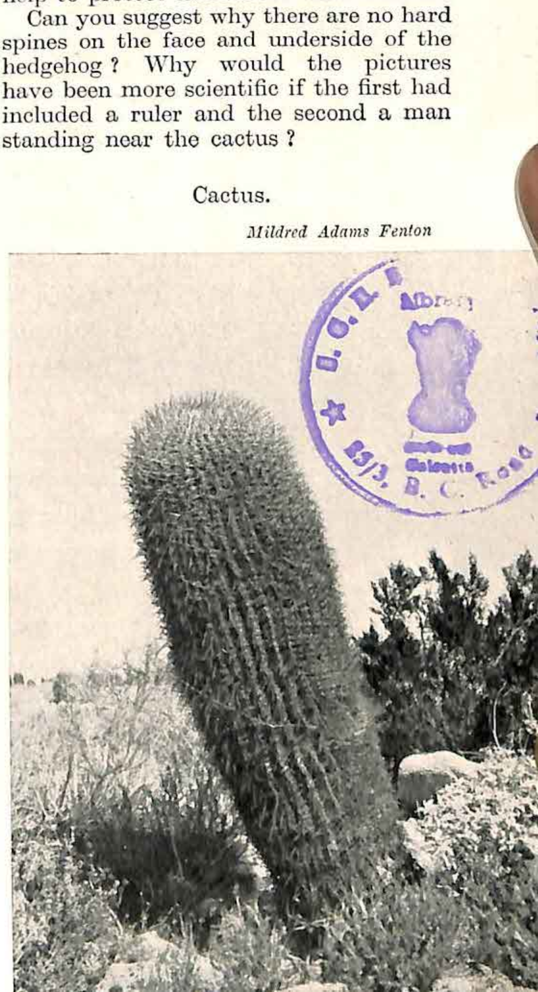
Hedgehog.

FIGURE 11. Some special adaptations. Spines of the cactus and of the hedgehog help to protect them from their enemies.

Can you suggest why there are no hard spines on the face and underside of the hedgehog? Why would the pictures have been more scientific if the first had included a ruler and the second a man standing near the cactus?

Cactus.

Mildred Adams Fenton



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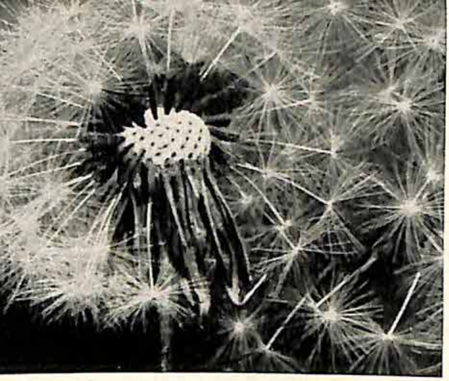
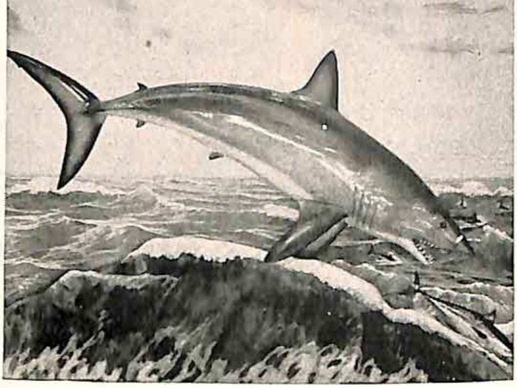


Harold Bastin

Dandelion.



American Museum of Natural History

Shark.

FIGURE 12. More special adaptations. Dandelion seeds have little parachutes and are often carried great distances by the wind. The shark's teeth are used for seizing food.

where many other plants will not grow. One of the reasons why the cactus plants survive is that they are able to store water for use during the weeks and months when rain does not fall. Another is that they bear sharply pointed spines. These protect them against many hungry animals. Similarly, hedgehogs protect themselves from their enemies by their spines. When they roll themselves into a ball not even a dog will attack them. A shark has a mouth armed with sharp, cutting teeth. They enable the shark to make short work of many fish upon which it feeds, or to ward off an enemy.

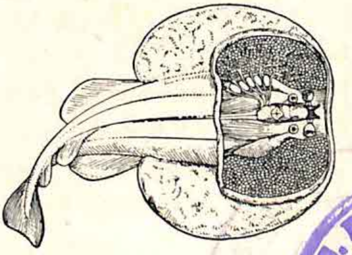
Note that the seeds of a dandelion have, every one of them, a little parachute so that they can be carried long distances by the wind. Such things as these wind-blown seeds, the teeth of a shark, the spines of a cactus, and the spines of a hedgehog are sometimes called *adaptations*. If you look at pictures of different plants and animals, or if you visit a zoo, botanical garden, or museum, you will be sure to see many more like them.

In what way are special adaptations useful?

When you stop to think about adaptations you will see that some serve one purpose and some serve another. The spines of a hedgehog give protection and so do the spines of a cactus. On the other hand, the teeth of a shark are mainly used in obtaining food. The structure of a dandelion's seeds favours scattering, so that some of the new plants may have good places in which to grow. Being able to ward off enemies, obtain food, and to grow, are things of great value to a plant or an animal. If they are not able to do such things they are not likely to last very long.

Electric organs. Certain adaptations are interesting, because they are so unusual. One occurs in the torpedo ray, as shown in Figure 13. It is a member of the shark tribe, and lives in the sea. On either side of its body are masses of cells which make up the so-called *electric organs*. These organs actually are able to give off an electric discharge which will kill or stun a small fish that ventures too close to the ray. It is in this manner that a ray gets some of its food. The electric organs can also be used to drive off possible enemies. The shock can be sufficiently powerful to be felt—and disliked—by fishermen. The torpedo-ray is only a special member of the ray family of fish, more commonly known as the skate family. The broad, powerful, fleshy fins of the skate make very good eating and are widely sold by fishmongers.

FIGURE 13. A drawing of a torpedo ray, with part of its upper surface removed to show the electric organs.



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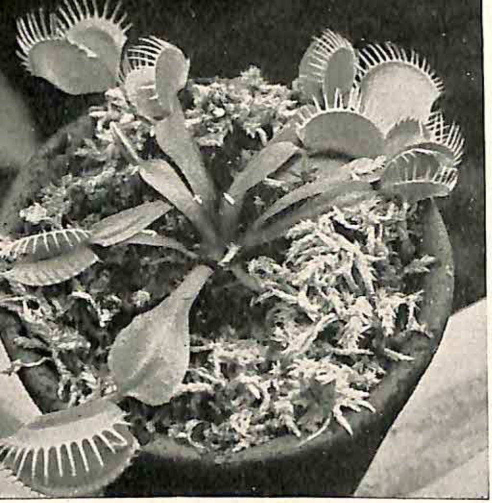

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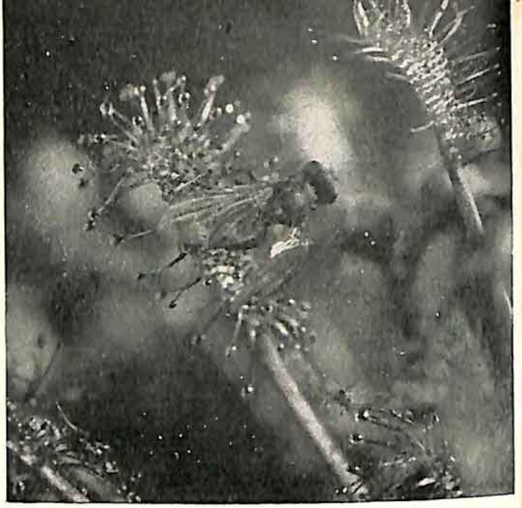
FIGURE 14. A Venus fly-trap.



Harold Bastin

Insect on Sundew.

A plant that traps insects. A plant which has an amazing adaptation is the Venus fly-trap. This little plant is found growing in some parts of the United States, and is noted for its ability to catch or "trap" insects. If you look at Figure 14 you will see what some of the "traps" at the ends of the leaves look like. When an insect lights upon such a trap, the two sides of the leaf close together, and the victim is captured. Then the cells of the leaf give out a chemical substance which dissolves the insect. British plants which do the same sort of thing, though their actions cannot be seen so clearly, are the Sundew, Bladderwort, and Butterwort.

Our hands. We ourselves have many adaptations of structure and behaviour, but most of them do not seem at all strange to us because they are so familiar. Our hands, however, are almost in a class by themselves because they can be used for so many different purposes. They can "handle" very small objects or tools, and operate all sorts of machines. With them we can write, obtain food, play pianos, throw balls, steer a car, sew garments, and do a host of other things. They have enabled us to use, and to gain control over, many things about us.

The adaptations that we have been thinking of in this question show certain ways in which living things survive. But remember that no matter how living things differ from each other, they are alike in being composed of cells filled with protoplasm.

SOME THINGS YOU MAY CARE TO DO

1. Prepare an exhibit of pictures showing plants and animals that have special adaptations.

2. Prepare and display a collection of plant seeds. Include " winged seeds," and other types that are likely to be scattered far and wide.

3. Visit a museum, or a botanical or zoological garden, and study cases of special adaptations, as shown by plants and animals.

4. Report on plants that trap insects and where to look for them.

5. The plants (and animals) of a terrarium may be used to study adaptations. To make a terrarium, do as follows : Use an old aquarium, or a large battery jar as a container. Place a layer of gravel or sand on the bottom to a depth of two or three inches. On this put three or four inches of good black loam. See to it that the soil is well moistened, and keep it moist. Visit the bank of a stream and get some lichens, liverworts, mosses, and ferns. Plant them in the terrarium. Cover it with a pane of glass (to prevent rapid evaporation), and put it in a fairly warm place near a window, where the sun's rays will fall upon it during the day. Frogs, toads, and some lizards may be kept in a moist terrarium.

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Problem B: WHAT DO PLANTS DO WHEN THE WEATHER CHANGES ?

You have known for many years that plants will not grow well, and that many of them die, unless conditions are favourable for them. But do you know what conditions are favourable and what kinds of weather are needed for good growth ?

Problem B: What do Plants do when the Weather Changes ?

Question I. How does Temperature affect Plants ?

To answer this question we do not need to carry out any experiments. Nature is always changing the conditions of temperature in most parts of the world and we have only to use our eyes to see the results. If you want to be like a scientist the first thing you must do is to train yourself in careful observation of what goes on around you. The little task that follows will test what you have already observed.

Write down the names of two garden plants (flowers or vegetables) which, provided that they have sufficient moisture,

(*a*) grow best when the weather is very hot,
(*b*) grow best when the weather is not so hot or when the plants are in the shade.

Then write down the names of two garden plants which

(*a*) are killed by the first frost,
(*b*) keep their green leaves in spite of frost.

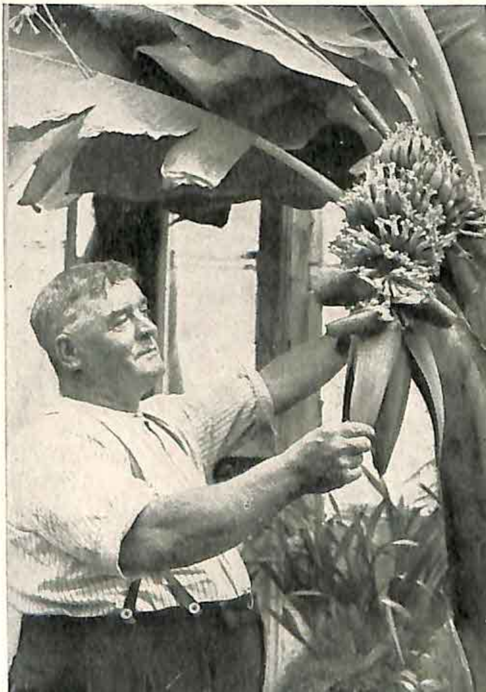
You may also think of plants which require such particular conditions of temperature that they have to be grown in special glasshouses where a high temperature is maintained by day and night. Have you ever visited such hot-houses ?

Things like these, which we can observe for ourselves, teach us that—

PLANTS VARY IN THEIR TEMPERATURE REQUIREMENTS

If you should travel to the Far North of Europe or Asia or America, you would find a great treeless expanse. Trees will not grow there because the average temperature is too low. The soil is always frozen solid, even in summer, to within a short distance from the surface. Since trees must send their roots deep into the soil if they are to nourish themselves, they cannot keep alive. Some willow trees, however, do grow in such places. But instead of becoming tall trees, they creep along the ground and so can manage to grow without deep roots.

In most of these northern parts the snow lasts through May at least, and winter begins again in



O. Ford Jones

FIGURE 15.

These bananas are growing under glass in the municipal park of the industrial town of Darlaston in the centre of England. The temperature is never allowed to fall below 65° F.

What would you guess about the water needs of banana plants? Give reasons for your answer. *Hint:* look at Fig. 11.

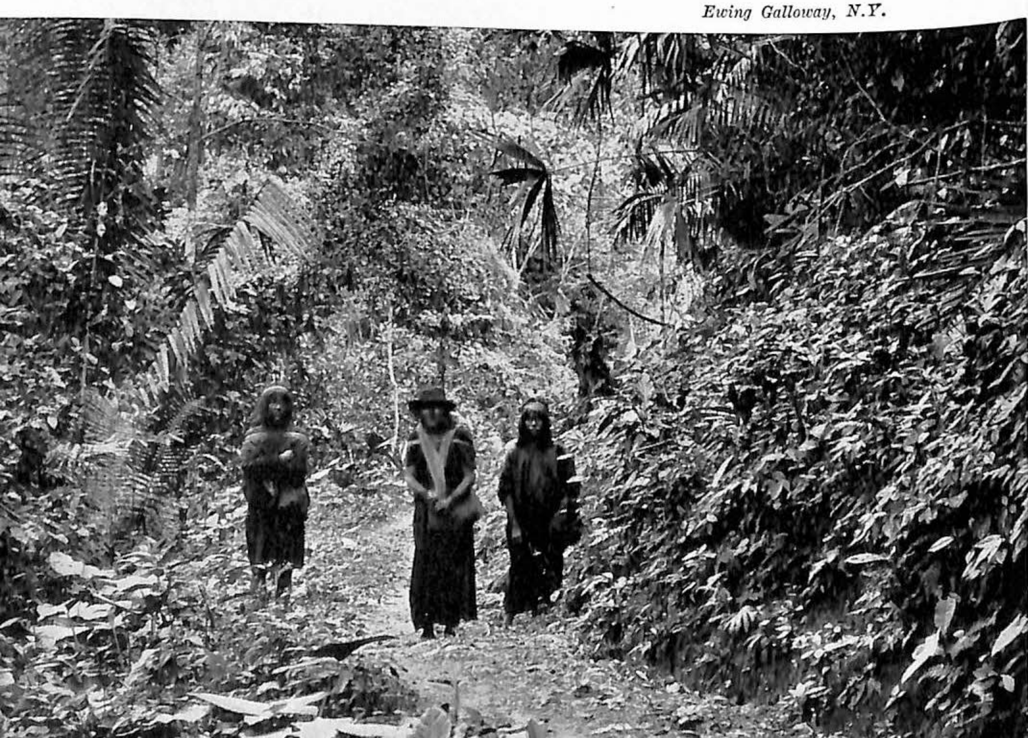
September, so there are only two seasons—a long winter and a short summer. But when summer does come, plants grow fast. Those which have bulbs under the ground spring quickly into bloom.

Contrast with these plants of the cold north the luxuriant vegetation of the dense tropical forests, such as in the Amazon Valley or the West Coast of Africa or much of Malaya and the East Indies, where heat and moisture combine to make plants grow to tremendous size. Here it is both hot and wet all the year round. Not only do we find huge trees of many kinds, but the trees themselves provide homes for other plants. Creepers of various sorts hang from them; ferns and orchids grow on their branches.

Some few plants can grow under conditions where most would perish. For example, in the Yellowstone National Park in the U.S.A. there are many geysers and

FIGURE 16. A jungle footpath near a head stream of the Amazon. Compare the plants with those in an English wood.

Ewing Galloway, N.Y.



hot springs. The basins and terraces built from the minerals dissolved in the hot water are of many hues—red, pink, brown, and bluish grey. These colours are not really due to the minerals but to the microscopic plants living in water so hot that most plants would speedily be killed. These, however, belong to the group of simple plants called *algae* (from the Latin word which means seaweed). There are many thousands of different kinds of algae ranging from forms like these, invisible to the naked eye, to the bladder-wrack seaweed which most of us know. Most algae are coloured. We shall read more about algae when we come to Problem D.

Why leaves change colour in autumn. Many people suppose that frost is responsible for the colour change in autumn leaves, but the true reason is quite different. Some leaves begin to turn long before we have any frosts. The real reason is a chemical change which takes place in the leaves. All during the spring and summer the leaves have served as factories where the foods have been made that are necessary for the trees' growth. This food-making takes place in numberless tiny cells in the leaves, and is carried on by the small green chlorophyll bodies which give the leaves their colour. In the autumn, when the cool weather causes the process to slow down, the little green bodies break up and so lose their colour, for their work is done. Then the leaves turn either yellow or red or brown.

There is always a certain amount of yellow colouring matter in leaves, but when the chlorophyll bodies are active, their green colour hides the yellow. When the green disappears, the yellow shows.

The reason for the red colour is different, however. Have you noticed that a certain tree may have red leaves on the side exposed to the most sunlight and mostly yellow leaves on the shady side ? Scientists who noticed this have made many experiments and have reached the following conclusion. There seem to be two conditions necessary to produce red leaves in autumn. The first is sunlight. There must be warm, bright, sunny days in early autumn, and at that time the chlorophyll bodies, which are still active, manufacture a great deal of sugar. Secondly, such days must be followed by cool nights, when the temperature drops to below 45 degrees. Sap movement slows down then, and much of the sugar is trapped in the leaves instead of being carried away to other parts of the tree. Some of the sugar changes to a new substance, which is red.

To sum up what you have learned, and answer the question as to the effect of temperature changes on plants, remember that plants vary. Why is it not scientific to make such a statement as " Freezing temperatures kill plants," or " No plants can live in hot water " ? You may be accurate, however, in saying that plants grow better in warm temperatures than in cold ones. You have learned, too, that as cold weather approaches, certain changes take place in trees and similar plants. Can you sum them up ?

SOME THINGS YOU MAY CARE TO DO

1. To show whether seeds need warmth in order to sprout, plant four or five bean seeds in each of two small flower pots filled with good soil which should be moist. Place one pot in a warm place and the other in a refrigerator or a cold place. Observe them for at least a week. What happens ?

2. Make a collection of pictures of plants that live in hot wet, hot dry or very cold climates.

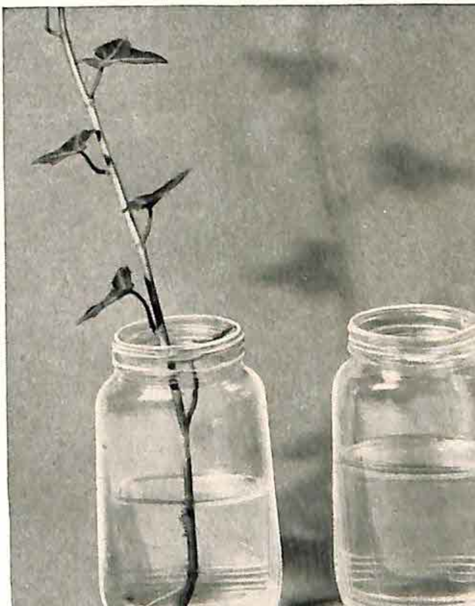
Question 2. Can Plants Live Without Moisture ?

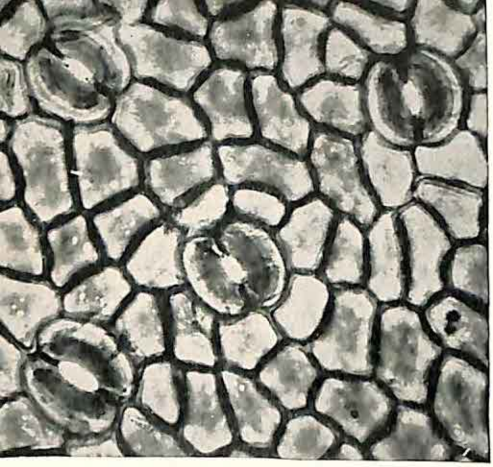
Everybody knows that plants have to be watered in very dry weather. A very simple experiment will show you what a quantity of water even one plant uses. Pour equal amounts of water into two glass jars as shown in Figure 17. In one of the jars place a small plant so that its roots are in the water, holding the plant in place with wire or narrow strips of lead. Then pour a thin film of olive oil or cooking oil on top of the water in both glasses. This film will keep the water from evaporating. If you measure the height of the water every day by means of a ruler, and keep a record of the measurements, you will find that the level of the water in the jar with no plant in it remains unchanged. But the water in the other jar drops a little every day. This can only mean that the plant is taking in water from under the oil film.

What is one use of roots ?

The next experiment will give results in a short time. It will show you where the water escapes from a plant. If you dip a piece of white blotting paper in a solution of cobalt chloride, which is pink, and then dry it over heat, it will turn blue. This colour change may be used as a test to show where water is leaving a plant. Cut pieces of the blue paper to cover both sides of a

FIGURE 17. This experiment has been going on for nearly a week. Explain the result shown.





Douglas F. Lawson

FIGURE 18. With a microscope you can see the tiny pores on the under side of a leaf. They allow the water to escape.

leaf of a living plant. Then cover the blotting paper with pieces of cardboard or glass to keep away atmospheric moisture. In a few minutes you may take off the paper. Do you find that the piece of test-paper which covered one side has turned pinker than that on the other side?

From which side of a leaf does water chiefly escape?

PLANTS THAT CAN STAND DROUGHT

If there is not enough water coming up through the roots to replace what is being given off through the tiny pores in the leaves, a plant wilts. If it is just beginning to wilt, it will revive when given water. But if the roots have completely dried up, no amount of water will revive it.

In some years certain parts of the world may have long periods of drought, when no rain falls. Then crops wilt and dry up. Even the grass may die. Many Governments are constantly carrying on experiments to find out what plants can live through drought.

There are some plants, as we know, that do live successfully with very little water. A scientist once brought a cactus plant from the Arizona desert and put it on a shelf in a museum. There it lived for eleven years on the water it had stored up inside its thick outer skin. Each spring during those years it put out new leaves.

The secret of living on little water is to avoid any loss taking place. A cactus plant, for example, makes its food with its stem, which is green, instead of in leaves as many green plants do. Either there are no leaves at all on a cactus or they are very small. So there are few pores through which water can escape.

SOME THINGS YOU MAY CARE TO DO

1. Find out whether roots grow towards moisture. Use a wooden box with a glass front. Divide it in two parts, as shown in Figure 19. Do not let the division extend more than two-thirds of the height of the box. Fill one side with very dry soil. Fill the other with soil which you keep moist. Soak some beans in water overnight and put them about an inch below the surface of the soil, just over the division, close to the glass. Watch your experiment for at least two weeks. In what direction do the roots grow ?

2. Select two small balsam plants and two cactus plants and plant them in pots. To one balsam and one cactus give *no* water. To the others give an eggcupful each day. What are your results and conclusions ?

After a fortnight give some water to the two plants that have been kept dry. Does this have any effect on either of them ?

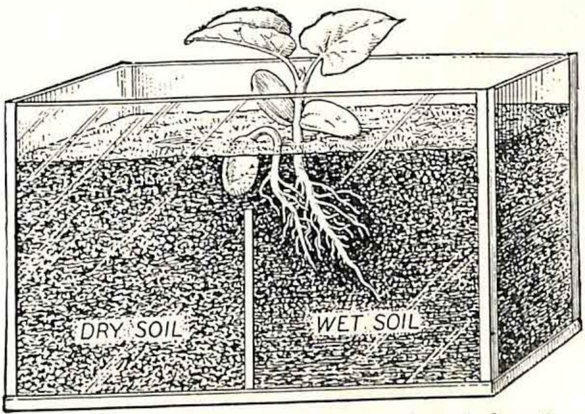


FIGURE 19. What does this experiment show ?

Question 3. **How do Plants Survive when the Weather is Unfavourable ?**

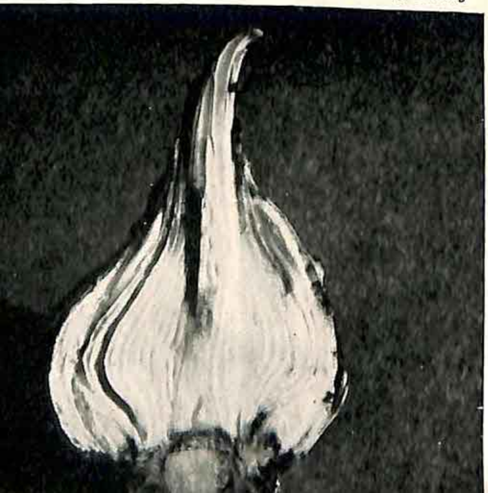
Everyone knows that flowers disappear when winter comes. But when the warmth and moisture of spring start growth in gardens and fields, certain plants appear and soon bloom again. Have you ever wondered how such plants can do this ? How can something that seems quite dead " come to life again " ? How do plants manage to survive the winter ?

Bulbs. You may have seen a field of yellow daffodils, perhaps even a field of wild ones. In the early spring they cover the ground with a carpet of gold. But look for the flowers in August or September—you find no sign of them. Daffodils are one of the many plants that survive the winter by forming *bulbs* underground.

If you examine a bulb of narcissus, you notice first that it is covered with a brown paper-like material. If you cut the bulb down the middle, you can see that it is really a clump of thickened white leaves. In the summer, when the bulb is forming, the leaves that reach up into the sunlight are green. They make food by means of their little green chlorophyll bodies, as all green leaves do. (See page 9.) The food passes down underground into the special leaves used for storage, and remains there until it is time for the plant to start growth. Is it good or bad to cut down the daffodil leaves after the plant has flowered ?

FIGURE 20. Thick storage leaves of a narcissus bulb.

Cushing-Gellatly



Corms. The gladiolus is one of the loveliest flowers of summer. Perhaps you have some in your garden ; they are among the easiest flowers to grow. In the autumn you dig up the *corms* (the underground part) and store them where frost cannot kill them. The corm you dig up is actually a new one developed on top of the one you planted in the spring, now black and shrunken. The corm is filled with plant food made by the leaves. It remains alive while stored in your cellar.

Seeds. Plants that live only one season are called *annuals*, as you probably know. You may think that in them we have examples of plants which do *not* survive the winter. It is true that the plant dies, but during its life it has been very active, making food in its green leaves and bearing flowers. The leaves have been necessary to keep the plant alive this year ; the flowers are just as necessary for producing seed for life *next year*. Annuals are not, of course, the only plants that produce seeds.

How some trees and shrubs are protected in winter. For our fourth example, let us think of a tree, such as the horse chestnut. Like many other trees, it loses its leaves in the autumn. The trunk and branches are bare. Is it dead, as it seems to be ? If it is winter we can easily tell by examining some of the twigs. Does your twig look like that shown in Figure 21 ? Find the large *terminal bud* at the end of the twig and the smaller *lateral buds* along the sides. In winter these buds are covered with a sticky, waterproof coating. If you cut one open, can you see the tiny leaves folded up inside, each with a soft covering like cotton wool ? In the big terminal buds, you can find, in the centre, the parts that will grow into the beautiful horse chestnut flowers.

These are four ways by which plants can survive when the winter cold comes and the weather is unfavourable. *Can you think of other ways ?*

SOME THINGS YOU MAY CARE TO DO

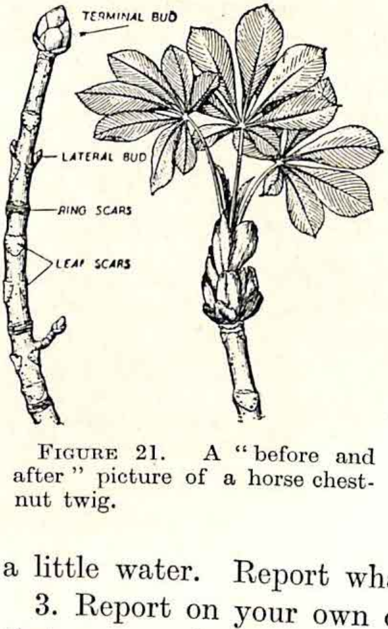


FIGURE 21. A "before and after" picture of a horse chestnut twig.

1. Show that the branches of a tree do not die in winter. In winter cut some twigs of willow, horse chestnut, hazel or other trees, and place them in jars of water in a warm room. Do the buds begin to change after a few days ?

If after a few weeks the leaves open out as shown in Figure 21, can you explain where the material has come from to make the leaves ?

2. Plant a few paper-white narcissus bulbs in a shallow dish partly filled with pebbles. Pour in a little water. Report what changes you observe.

3. Report on your own observations of plants and their ways of surviving unfavourable weather. For example, how do violets continue their life ? In what form do potato plants survive ? Can onions live from year to year ?

Problem C: **WHAT DO ANIMALS DO WHEN THE WEATHER CHANGES?**

This problem is a very big one. A scientist might well spend months, even years, in making studies of numbers of different animals and how they behave in winter and in summer, in fair weather and in storms. In the few days that you can devote to this problem you can get but a glimpse into this fascinating side of animal life. But if you continue to observe living creatures around you, in the air, on plants, and in the ground, you may discover for yourself more valuable information than any book can teach you.

Problem C: What do Animals do when the Weather Changes?

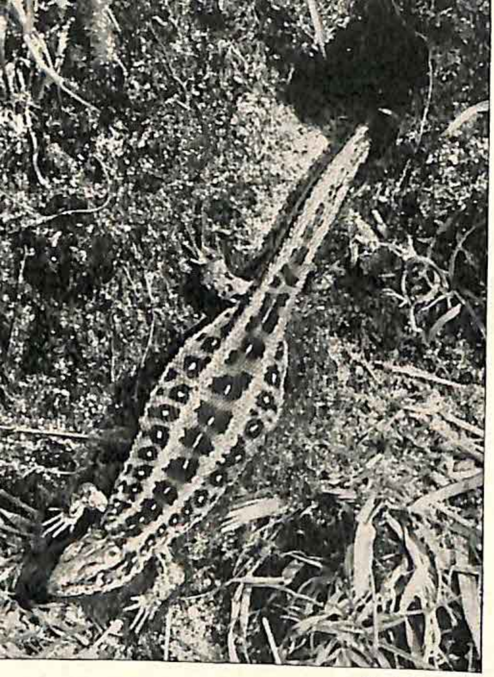
Question I. **How do Temperature changes affect some Animals?**

When you are ill, the doctor takes your temperature with his thermometer. If he finds the reading to be about 98·4° F., he says that your temperature is "normal." A few people have slightly higher or slightly lower normal temperatures, but 98·4° is the average. Do you think that it makes any difference to your temperature whether you are in a warm room, or outdoors on a cold day? To find the answer to this question, someone in the group could have his temperature taken under different conditions.

Does the surrounding temperature affect the temperature of the human body?

"WARM-BLOODED" AND "COLD-BLOODED"

We are so accustomed to keeping always at nearly the same temperature that we usually do not give it a thought. Practically no animals except birds and mammals can maintain a constant temperature. The temperatures of all other animals and of all plants go



Paul Popper

FIGURE 22. As this "cold-blooded" sand-lizard moves from the shade into sunshine the temperature of its body goes up. Why does its temperature change?

up and down with the temperatures of their surroundings. And as their temperatures go up and down, so do their activities. You seldom see an insect out-of-doors in winter because either they are dead or they are so cold they cannot fly or in fact move at all. If they do not die they become *dormant*, which means passing the cold time of year in an inactive condition. Animals which act in this way are usually called "cold-blooded," but really they are animals with changing temperatures. One scientist found that he could use the activity of ants as a thermometer. The warmer the weather, the faster the ants moved. So, by measuring the rate at which they walked along a certain path, he could find the temperature fairly accurately.

Birds and mammals, unlike insects, spiders or frogs, keep their temperature fairly steady, or constant. This ability is of advantage to them, for they can be just as active on a cold winter day as on the hottest day in summer. Like human beings, they are all the time producing heat by the chemical processes inside their body cells. They are also losing heat constantly from the surface of their bodies.

Many animals with a constant temperature have a thick coat of fur or of feathers, which helps to control the amount of heat which escapes. Have you noticed birds sitting on the branch of a tree or on a wire looking all puffed out ? The fact is that they can move their feathers by means of little muscles, and on a cold day they move them in such a way as to enclose a great deal of air in the little spaces between the feathers. Air is a poor conductor of heat, so when the birds fluff out their feathers, they lose less heat than usual. The same sort of thing happens in the case of some hairy animals, especially those with thick fur. Have you noticed that a cat's fur seems thicker out-of-doors on a cold day ?

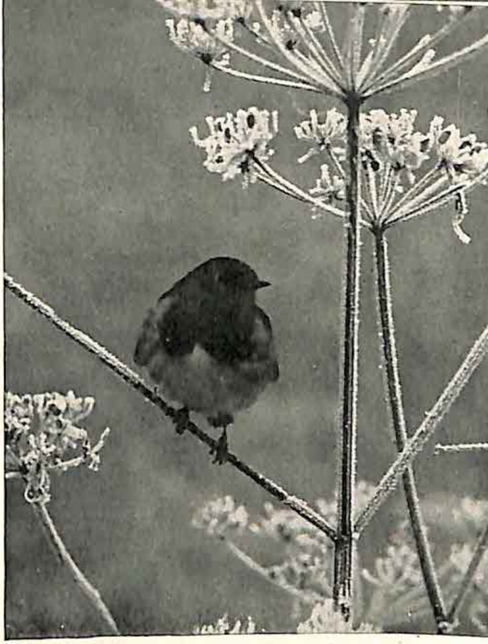
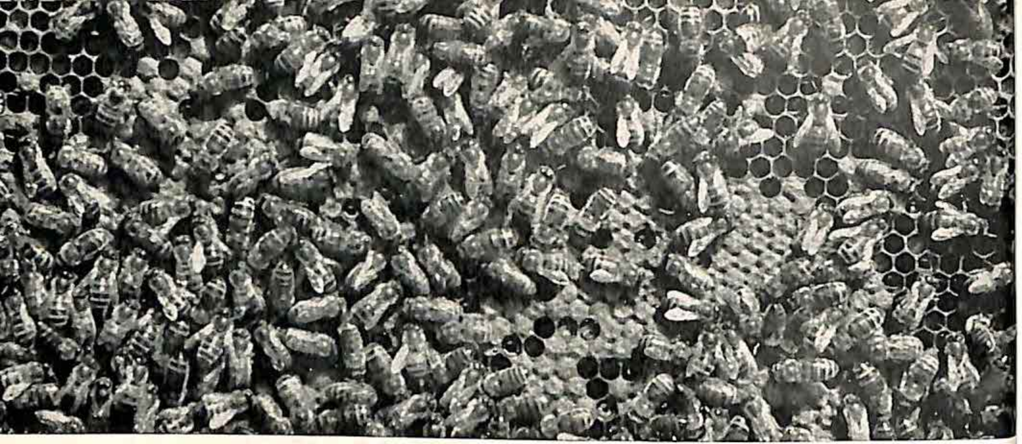

John Markham

FIGURE 23. How does fluffing out its feathers help the robin to keep warm on a frosty day ? Can you see the frost on the plant ?

Hibernation. When the outside temperature gets very cold, animals such as hedgehogs, squirrels and some bats go into the hibernating condition, in which their breathing and other life processes are slowed down greatly. Many other animals, not in the class called mammals, also hibernate in cold weather. Future queen wasps hang like little Egyptian mummies in the folds of curtains or of sacking in a shed or against the rafters of a warm loft. Frogs bury themselves in the mud at the bottom of ponds. If you dig up a hibernating frog, you may think it dead. But if you then take it into a warm place, the heart which had been beating so slowly that you didn't think it was beating at all, will begin to beat faster, the frog's temperature will rise, and soon the frog will be as active as ever.



Eric Hosking

FIGURE 24. Bees cluster close together when it is cold.

Bees in a hive. Bees are insects and do not regulate their own body temperatures, but all the bees in a hive are together able to regulate the temperature of their home. When the weather is hot, the worker bees gather in the passages of the hive and use their wings to make a current of air. If it is cold, the workers crawl quickly about, using energy, and giving off heat. By these means the temperature of the hive is kept steady while the grubs are developing.

In winter there are no grubs in the hive, so the temperature is not kept as high. But bees do not really hibernate. If the temperature of the hive falls below about 55 degrees, the bees gather in a dense mass and crawl about. This raises the temperature of the whole group.

In summing up the ways in which temperature changes affect animals, we may say first that the animals must be considered in two groups—those whose body temperature is more or less constant and those whose body temperature varies with the surroundings. We must remember, too, that each of the thousands of different kinds of animals has a way of its own, a few of which are slowing of activity, *hibernation*, and moving to a more favourable place or *migration*.

SOME THINGS YOU MAY CARE TO DO

1. Using a clinical thermometer, take the temperature of your pet dog or cat under different conditions. Does it vary ?

2. After consulting books of reference prepare a report on the way in which some particular animal passes the winter.

3. Report on the migration of some sort of bird, drawing a map using a definite plan such as:

Summer home of the birds chosen. Winter home. Route followed, with dates if possible.

You can get help from the Royal Society for the Protection of Birds, 25 Eccleston Square, London, S.W.1.

Question 2. **How do Men protect themselves from Uncomfortable Weather conditions ?**

Birds ruffle up their feathers to keep warm, as you saw in Figure 23. Men can produce the same result by putting on thicker clothes. On a hot summer day we like to wear as little as possible ; then the air can get to our skin and carry heat away. But on a very cold day we like to wear several layers of clothes. We thus enclose several layers of air, which is a poor conductor of heat. These layers of air keep the body heat from escaping. In winter we like to wear clothes made of wool or of fur, both of which materials imprison a great deal of air between their fibres.

In winter, too, we usually wear darker clothes than in summer. There is a scientific reason for this, which a simple experiment will illustrate. Figure 25 shows the apparatus. Two thermometers are attached to cards, the first to a white card and the second to a black card. Each card is supported six inches away from a lighted electric lamp. At three-minute intervals

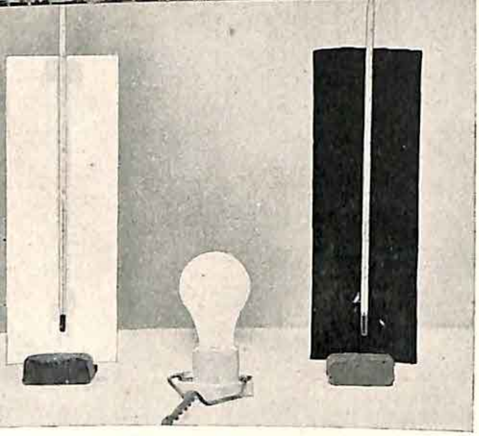


FIGURE 25.

the temperature registered by the thermometers should be recorded.

Does the light or the dark card seem to absorb more heat in a given time?

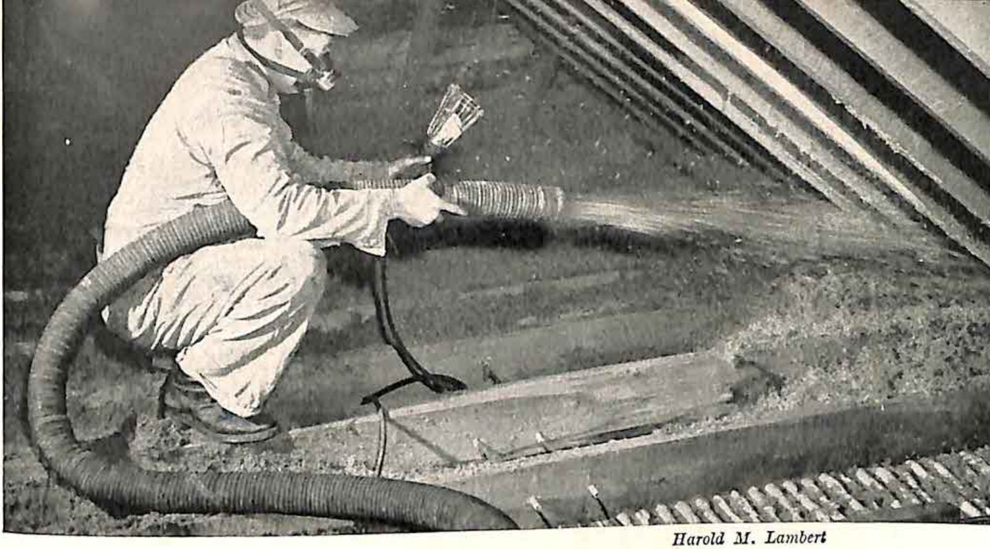
Why is white clothing more comfortable for summer than black clothing?

PROTECTION AGAINST THE WEATHER

Clothing. The materials in our clothes absorb or reflect sun energy. White clothes reflect most of it, and therefore do not get very hot. Dark materials, on the other hand, absorb more than they reflect, and are therefore warmer, especially when they are in the direct rays of sunlight.

Excessive heat or excessive cold are not the only weather conditions which make us uncomfortable. Another is very wet weather. When it rains or snows, we seek shelter, and when we must be out-of-doors, we wear waterproof clothing if possible. Until quite recent times rubber was the common material used for waterproof clothing. Now, however, many fabrics are available including *plastics*. Do you know how plastics are made and from what materials? If not, can you find out?

Shelter. The subject of shelter from uncomfortable weather is too extensive to treat fully at this point. Since the earliest times men have made shelters for themselves and their families, using materials which were easily obtained and suitable for the purpose. Mud, stone, wood, brick, steel, plaster, ice, hides—



Harold M. Lambert

FIGURE 26. Insulating a house.

these are some of the materials men have used. Can you name the advantages of each?

One modern scientific development which we must not overlook is that of insulation, that is, ways of preventing the passage of heat. It is a fact that your home, no matter how tight against weather, is far from being "heat-tight." Its walls and roof permit the inflow of oppressive heat in summer and the outflow of manufactured heat in winter. In modern buildings some form of insulation has come to be used.

Materials for the insulation of homes are in general either (1) insulating boards made of some kind of fibre; (2) "blankets" or "quilts" of special material which may be folded or stuffed into place; or (3) filling materials which may be blown into all the nooks and crannies of the walls and roof. Cavity walls which hold a layer of air play the same part but are not sufficient in cold climates. The fact that insulation is a barrier to the passage of summer heat into our homes, as well as winter warmth to the out-of-doors, makes it well worth while.

In thinking of the scientific reasons behind man's methods of protecting himself from uncomfortable weather, we note that both in the case of suitable clothing and in that of home insulation, comfort is due to the presence of air. It is because still air is such a poor conductor of heat that we make our warm clothing of materials that hold air in the spaces between the fibres. And it is also because still air is such a poor conductor of heat that we use "rock-wool," or "quilts" made of shredded paper or cotton to fill the spaces in the walls, floors, and roofs of our homes. In "cavity walls" in England still air itself is the insulator and no filling is considered necessary.

In the case of suitable clothing for different climates, we note that choice depends on whether or not the material *absorbs* heat from the sun's rays. And in the case of waterproof fabrics, choice depends on how far the material does *not* absorb water.

What would you now say in answer to the question: "What do animals do when the weather changes?"

SOME THINGS YOU MAY CARE TO DO

1. Arrange a series of test tubes, each with one inch of water in the bottom. With wire clips fasten strips of different kinds of materials so that they extend to the bottom of the tubes. Aften ten minutes, measure the height of the water in each tube. Make a list of the materials tested in the order of their waterproof quality, as shown by this test.

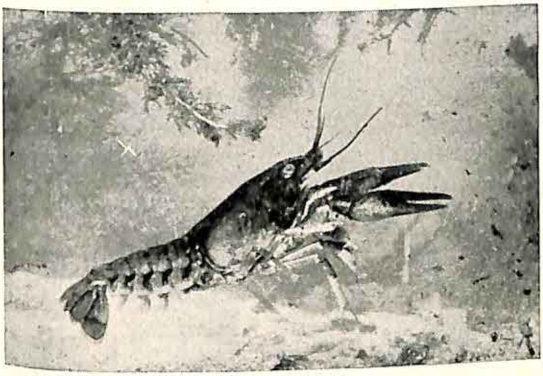
2. Collect pictures of houses, including prefabricated ones, suitable for different climates and describe the advantages of each.

3. Report on different methods used to control temperature inside buildings.

Problem D: HOW DO PLANTS AND ANIMALS GET FOOD?

Have you ever eaten any crayfish, sharks, seaweed, snails or frogs? Think carefully before you answer, for it is possible that you may have done so, especially if you have visited the Continent. Crayfish is sometimes used instead of lobster in preparing certain dishes. Some of the gelatin which is used in food is made from the fins of sharks. Certain types of seaweed, such as Irish moss, also yield a gelatin and are used in invalid cookery. Another kind of seaweed, laver, is widely used as a food in S. Wales and on the shores of Japan is actually cultivated. Certain snails and frogs are eaten in a number of countries, including France.

FIGURE 27. Do you know how these living things are used as food?



Henry B. Kane

Crayfish.

Bamboo plant. Note the size of the man.

Arnold Arboretum

Seaweed.

Mildred Adams Fenton

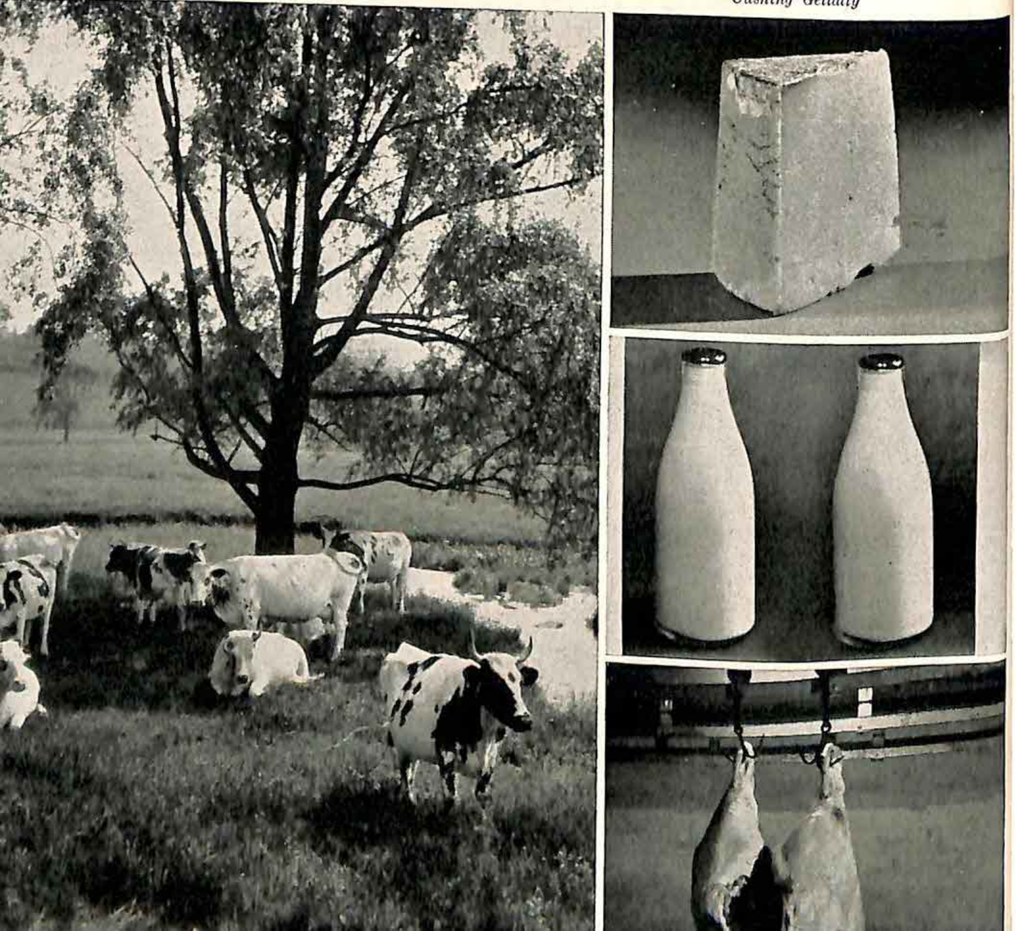
Young bamboo shoots are a standard food in the Far East. One could go on naming a multitude of strange foods which are eaten in our own and other countries. It would show that man eats a very large number of foods indeed—some from plants and others from animals.

Getting an adequate food supply has always been one of the great problems of mankind. Today it is a world-wide problem and that is why the United Nations set up a Food and Agriculture Organization to help nations produce more food, particularly in the most needy areas. Write to F.A.O., Rome, Italy, for free information.

FIGURE 28. What is the story that these pictures tell?

H. Armstrong Roberts

Cushing Gellatly



In the next few pages you will learn more about how foods are made and how they are used by plants and animals. You will also learn more about the foods that we eat ourselves, about the things that they contain, and the particular foods that our bodies need.

Let us begin by asking ourselves where foods come from. Some of the story is told by what you can see in Figure 28. How is the grassy meadow related to the cow? What are some food products that we get from this animal? You can get information on milk products from the National Milk Publicity Council, Melbourne House, Aldwych, London, W.C.2. Do the sunlight and the stream shown in the picture have anything to do with the story? You can find the answers to these questions in the pages that follow.

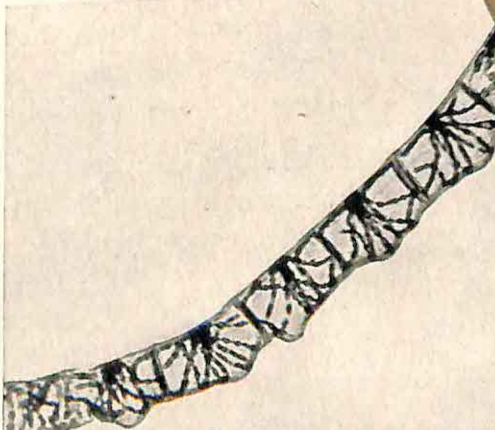
Problem **D**: How do Plants and Animals get Food?

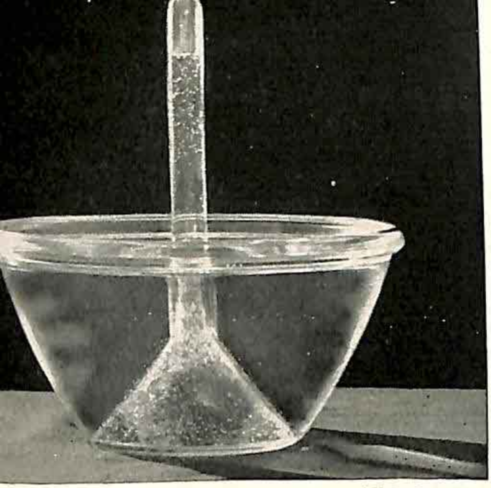
Question **1**. How do Green Plants get Food?

Except for such examples of insect-eating plants as we met on page 22, green plants cannot eat solid substances in the way animals do. But they can and do make their own food, as we have already learned, whether they live on land or in water.

Let us take some " pond-scum " from a pond or an aquarium. Such green mats or scum upon the water's surface are floating masses of simple plants. Place a few of the threads on a slide, add a drop of water and a cover glass and then examine with a microscope. You will see that each thread is made up of cells arranged end to end, and that within the cells are

FIGURE 29. Cells making up the filament of a simple plant, greatly enlarged.





Michael Smith

FIGURE 30.

greenish bands. These bands are green because they contain chloroplasts (see page 9) spaced along them like cut-glass sparklers mounted on a ribbon.

Let us now take some more of the "pond scum" and place it beneath an inverted funnel in a jar as shown in Figure 30. A test tube is filled with water and is then carefully placed over the funnel in the position shown, without allowing any air to enter it. If the jar is now placed in sunlight for a little while bubbles can be seen to arise from the green plant and collect at the top of the test tube. After some hours, when about an inch of gas has collected at the top, carefully remove the test tube, sealing its mouth with your thumb. Then, putting the test tube the right way up, so that the gas is near the mouth, carefully but quickly push into the gas a glowing splint. If this splint bursts into flame the gas is almost certainly oxygen—that constituent of the air which is essential for life.

Scientists have found out that in the presence of chlorophyll and sunlight (which supplies the energy), water and carbon dioxide are changed into simple sugar and oxygen:

water + carbon dioxide (+ energy) → simple sugar + oxygen.

The sugar is, of course, retained by the plant. Some of the free oxygen is also used, but when food-making goes on rapidly, a good deal of oxygen is discharged.

In a similar way sugar is formed by the chlorophyll in green land plants.

Look at Figure 31 which shows a magnified view of a thin slice of a leaf. In this you will see a vein which brings to the leaf-cells the water and other substances absorbed by the root. You will also see the pores on the underside of the leaf through which air (which contains carbon dioxide) enters the leaf. In the cells you will see the little chloroplasts that do their work when the sun shines. Like the chloroplasts of the simple plant from the pond they join carbon dioxide and water together to make sugar.

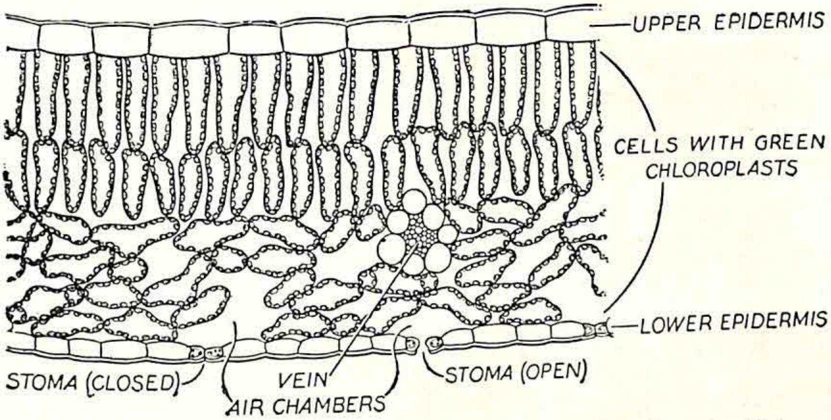


FIGURE 31. Drawing of a section of a leaf, greatly enlarged. Note the tiny holes on the lower surface. These are the openings through which gases may enter or leave the leaf. You can see these openings in the photograph in Figure 18. *Stoma* is a Greek word meaning *mouth*. Note the "guard cells" on each side of a stoma and compare with Figure 18.

SOME THINGS YOU MAY CARE TO DO

1. Examine the lower side of a green leaf, using a lens. See if you can find any openings. If a prepared slide of a leaf cross-section is at hand, look at it with the aid of a microscope. See if you can find any of the things shown in Figure 31.

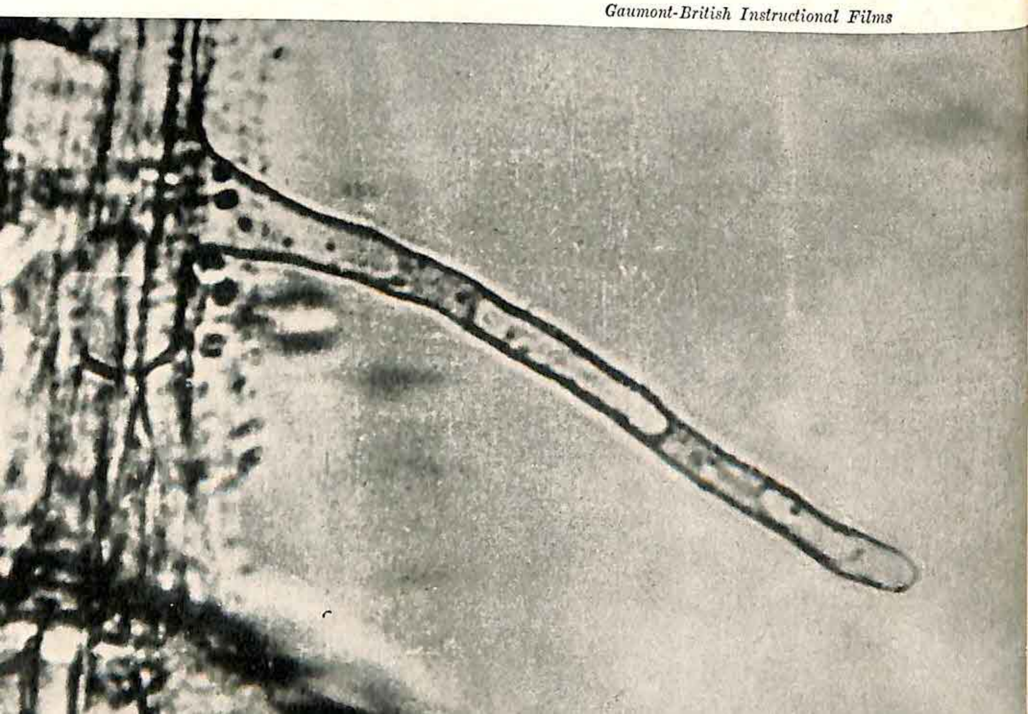
2. The word *epidermis* in Figure 31 means *outer skin*. By thinking of other words containing *derm* can you reason out which part of the word means skin?

You probably know what a *hydrant* is. How does this knowledge help you always to know what the word *carbohydrate* means?

3. Fill two or three flower-pots with moist sand, and plant some bean or radish seeds. Place the pots where the young plants will receive sunlight, and keep the sand moist. Observe the growth of the seedlings. When the young plants are two or three inches in height, remove one of them from the sand, being careful not to break up the root system. Wash it gently under a tap, place one or two rootlets on a microscope slide, and examine them with a microscope. See if you can find what is shown in Figure 32.

FIGURE 32. This is a photograph, taken through a microscope, of one of the root hairs growing on roots. These root hairs draw in the water from the soil.

Gaumont-British Instructional Films



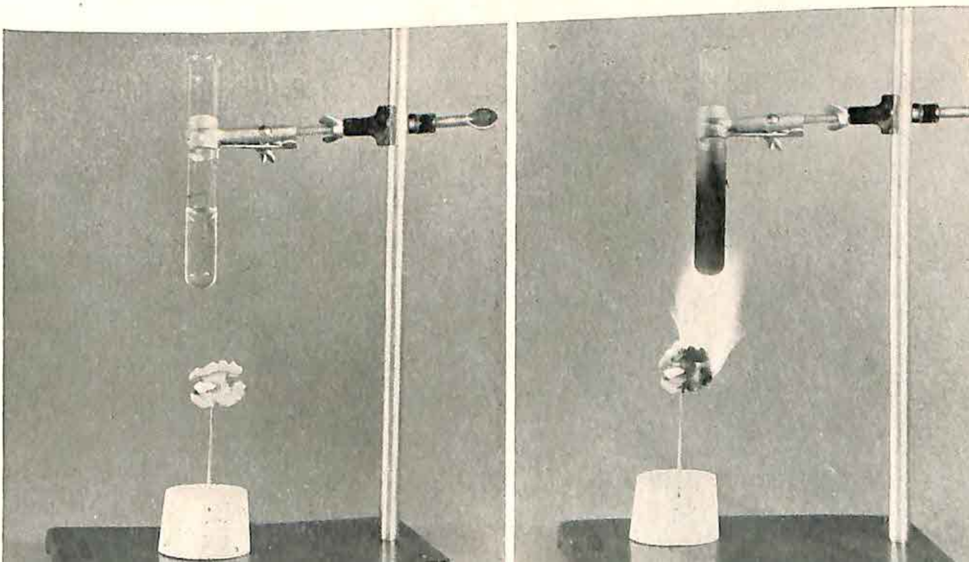
Question 2. **What Kinds of Food are there ?**

Starch. We have already learned that sugar is made of carbon and water and that substances made up like this are called *carbohydrates*. Starch is such a substance and many plants change sugar into starch as a way of storing for the next generation. Seeds are really microscopic plants wrapped up inside a food supply on which they will live during their early growth. The food supply of many seeds is starch. The wheat grain is a good example of this. So is the potato, but it is not a *seed*. What has it to do with the next generation ?

To test for the presence of starch pour a few drops of iodine solution on the substance. Try this on a crushed grain of wheat, on some flour and on a piece of potato and observe what happens.

Fats and proteins. Green plants, however, make other foods besides sugars and starch. In some way, not fully understood, plants change some carbohydrates into fats. They build up others into proteins. Some nuts, for example, are rather oily (fat), and will burn

FIGURE 33. Burning a walnut kernel to heat a test tube of water.

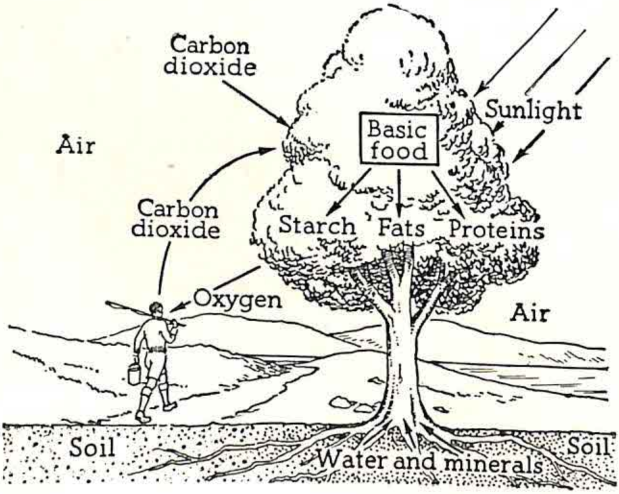


brightly, as shown in Figure 33. Plant tissues also contain protein; in certain cases the amount present is quite large. In the case of beans, protein may be as much as one fourth of the total substance.

Mineral substances. Plant tissues, like those of animals, contain various mineral substances. These are not present in large amount, but seem to be necessary for growth and well-being. Nitrogen from some of them (sodium nitrate, for example) is used in making proteins. Such mineral substances are taken into plants in soil water.

Food-making in a land plant. Figure 34 will help you to understand the food-making process in a land plant. Carbon dioxide of the air enters through pores in the leaves. Water carrying mineral substances in solution is taken in by the root system. Sunlight falls upon the green leaves, giving the energy necessary for making foods. Under these conditions foods are made and oxygen is set free. Some of this oxygen is returned to the air.

FIGURE 34. Food-making in a land plant.



SOME THINGS YOU MAY CARE TO DO

1. Put a small piece of potato in a dish that will stand a lot of heat. Place the dish on a clay-pipe triangle over a Bunsen flame. Heat the potato until it is reduced to an ash. What does this ash represent ?

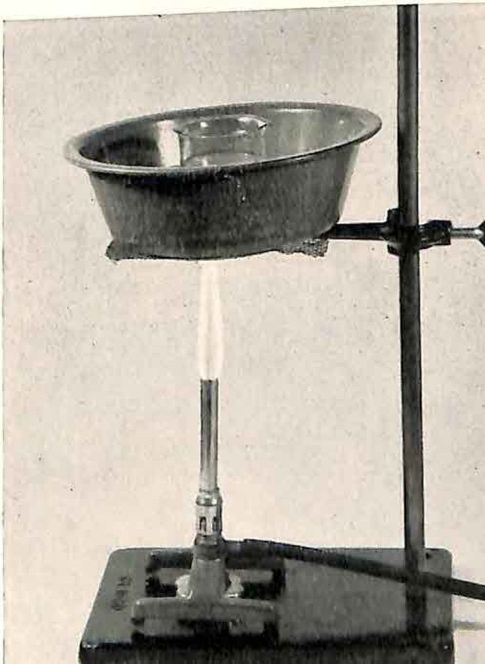
2. *With the aid of your teacher*, learn to test a green leaf for the presence of starch. It is first necessary to get the chlorophyll out of the leaf by putting it in hot alcohol, but it is dangerous to heat alcohol except in a water bath. The arrangement for this is shown in Figure 35. Put a large dish containing water on a wire gauze over a Bunsen burner. Now place a smaller beaker containing the leaf and alcohol in the water. The hot water heats the alcohol. When the chlorophyll has been dissolved out of the leaf, place the leaf on a piece of blotting paper and test it with iodine solution.

3. Butter and lard contain large amounts of fat. Smear the surface of a piece of ordinary white paper with one of them. Note the glazed effect. Now see if you get the same effect with wet starch, wet sugar or egg white.

4. By using your library prepare a chart showing common foods high in their content of (*a*) protein, (*b*) carbohydrates, (*c*) fats.

5. Consult a keen gardener, or some gardening books, about the following mineral fertilizers and their special values : lime, potash, and superphosphate. Find out what plants grow best, and which grow least well, in soil rich in lime.

FIGURE 35. Set-up for heating alcohol. The metal pan is half-filled with water.



Question 3. **How do Plants and Animals Use Foods ?**

Having learned what foods are needed by the body, let us now see how they are used. In studying living things, you have found that plants and animals are composed of cells. So is the human body. Look back at the pictures of human cells shown in Figure 7 on page 14. It may be interesting to try this experiment. Run the tip of a clean finger over the inside surface of your cheek. It is lined with several layers of cells, and some of them are always breaking free. Now smear the surface of a glass slide with the moist fingertip, add a drop of water and cover with a cover glass (to prevent rapid drying). Focus upon the slide with the low power of a microscope and you will see many flat, irregular cells like those shown in Figure 36.

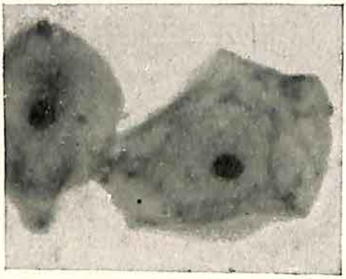


FIGURE 36. Stained cells, (× 425), lightly scraped from inside of cheek. *Flatters & Garnett.*

Since these cells are being lost from the inside of the mouth all the time, they must be replaced in some way. *What provides for growth and repair of such cells ?*

ENERGY, GROWTH, AND REPAIR

Foods provide materials for growth and repair. The answer to the question above tells part of the story of what plants and animals do with foods. The general nature of this story is the same, whether we are talking about the human body, a dog, or an elm tree. In early life more and more cells are being formed as the plant or animal grows. Foods, and especially the proteins in foods, provide the material from which they are built. As a plant or an animal approaches full size, the rate at which new cells are formed slows down. But food substances are still needed to repair or replace old ones that have become worn out. The cells that you remove from the lining of your cheek have become old, and are being replaced by new cells that grow beneath them. Similarly, new cells must be formed when a cut or a scratch heals. The needed materials come from foods that you have eaten and digested.

Foods provide energy. Another reason why both plants and animals—and man too—must have a fairly constant supply of foods is that they supply the energy needed to do the work of the body. When you run, or walk, or move a finger, muscle cells in various parts of the body do work. They can keep it up for a long time, but sooner or later they must have new supplies of the substances that come from foods. Energy is likewise needed to keep your heart beating, your lungs working, and for the many things that other parts of your body must do. The nutrients commonly used for such purposes in the human body are the carbohydrates and fats.

Oxygen–carbon dioxide cycle. Before leaving this subject, there is one other fact you should know. It has to do with oxygen and carbon dioxide. Scientists have learned that oxygen is used in the cells of a plant or animal in somewhat the same way that it is used when fires burn. It is from the slow burning of the cell materials that the energy for doing the work of the cell is obtained. Either slow or fast burning is called *oxidation.* You have seen that carbon dioxide is given off when fuels burn. It is also given off when materials in a cell are oxidized. Animals discharge carbon dioxide as a waste product. Active green plants set free more oxygen in making foods than they can use. So, as shown in Figure 34, the oxygen set free by green plants (see page 46) is used by animals, and the carbon dioxide thrown off by animals can be used by green plants. Sometimes this exchange of gases is called the oxygen–carbon dioxide cycle.

How would you now answer the question : " What kinds of food are there and how do plants and animals use them ? "

SOMETHING YOU MAY CARE TO DO

Prepare a large chart of the oxygen–carbon dioxide cycle. Show several plants and animals in it.

Problem D : How do Plants and Animals get Food ?

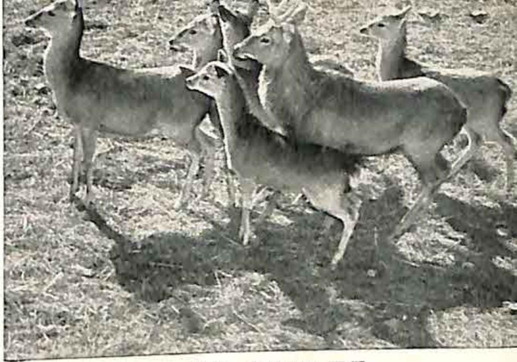
Question 4. **What do Animals Eat ?**

We have already learned that some foods are used to supply energy, that some are stored and that others provide for growth. Unlike plants, no animal is able to get nourishment from carbon dioxide and water, whether it receives the energy of sunlight or not. Since animals cannot *make* foods, they must obtain them in other ways.

No doubt you have seen many different kinds of animals eating. We can also add to what we already know by studying the food habits of various small animals that can be kept in the classroom. If you have an aquarium with a fish in it, try dropping a few biscuit crumbs upon the surface of the water. See if the fish will eat them. Put several grasshoppers in an insect cage and supply them with some fresh grass. If you have some white rats, mice or a rabbit, see what foods they will accept. Notice *how* the animals eat as well as what is eaten.

Do all animals eat the same things ?

Do all animals eat in the same way ?



Ewing Galloway, N.Y.

Figure 37. A herd of deer.

What you learn from such study, together with what you may recall about animals, will assure you that the answer to both of the questions above is NO. Some animals will only eat certain things. You will find, for instance, that certain animals in a terrarium or aquarium are rather hard to provide for, while others do not appear to be so particular.

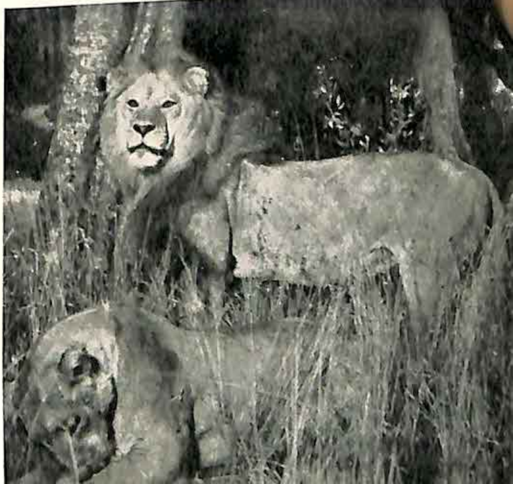
Plant-eaters. Figure 37 shows some large animals that feed upon plants. To the same general group you could add horses, giraffes, bison, cattle, elephants, and many others, not to mention the smaller types, such as squirrels and grasshoppers. These animals go directly to the green plants for their food.

Flesh-eaters. If you have visited a zoo or a circus, you may have seen a lion, perhaps even in the act of eating. In any event, it is well known that lions eat meat. So do panthers, hyenas, wolves, jackals, hawks, owls—yes, even some of the insects that prey upon other insects. Our tame dogs come from ancestors that were only flesh-eaters, but most dogs will now eat other foods as well.

Figure 38. Lions.

Deer are plant eaters—herbivores. Lions are flesh eaters—carnivores.

Ewing Galloway, N.Y.



Animals that eat many kinds of foods. Finally, there are some animals that eat a wide variety of both plant and animal materials. One of these is the domestic pig. Most of the things that we feed to pigs come from plants, but pigs will eat flesh when they can get it, and their wild relatives eat many foods. Domestic mice and rats will eat almost anything of plant or animal origin. Such animals have a great advantage, because they will find things to eat where others would starve.

In thinking about the food of animals, one thing in particular should be noticed. Some eat green plants directly. Some eat other animals, or both plants and animals. But the animals eaten either are plant-eaters, or feed upon plant-eaters themselves. Everything, then, depends upon the green plants. Green plants make the basic food, and feed the world.

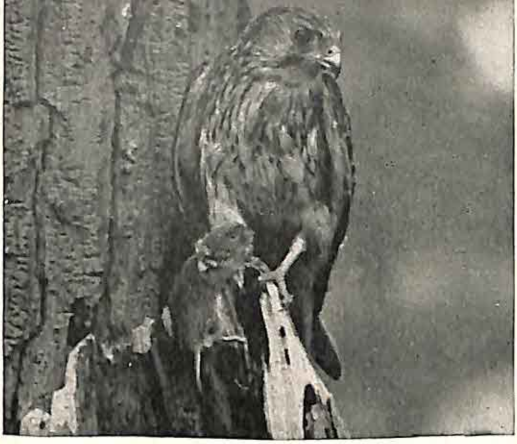
SOME THINGS YOU MAY CARE TO DO

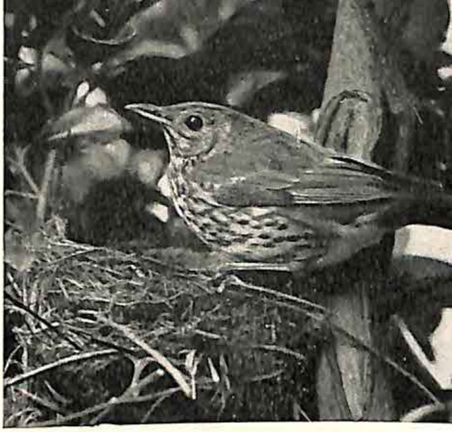
1. Examine the skulls of plant-eating and flesh-eating animals. Make a comparison of the teeth. Find out why the teeth of a cat or dog are well suited to eating flesh.

2. Compare the mouth parts of an insect, such as a mosquito (sucking type), with those of a grasshopper (chewing type). Be prepared to tell what this examination shows you about their habits. *Hint :* Can you find pictures or charts which show these structures ?

3. Using books on aquaria, prepare a report upon the food of aquarium animals, to include fish, crayfish, snails, newts, lizards, and others that you may find discussed.

4. Prepare food chains which show how some common animals of your community are dependent upon green plants for food.





Eric Hosking

FIGURE 39. A hawk.

FIGURE 40. A thrush.

Problem D: How do Plants and Animals get Food?

Question 5. **How do Animals get Food?**

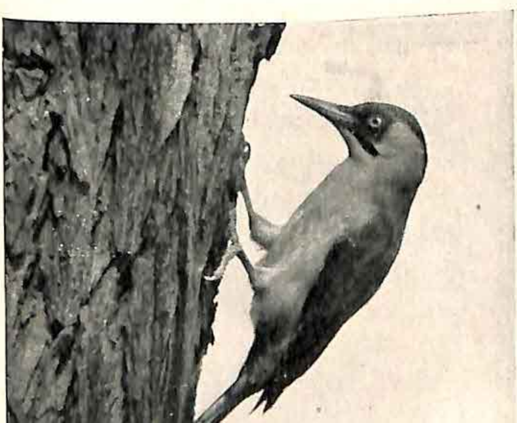
No doubt you already realize that animals have various structures which are of use in getting food. These are special adaptations, similar to those studied on pages 19 and 20. Pictures or film-strips of various birds and animals, like those in Figures 39 to 45, will show you more clearly what these adaptations are.

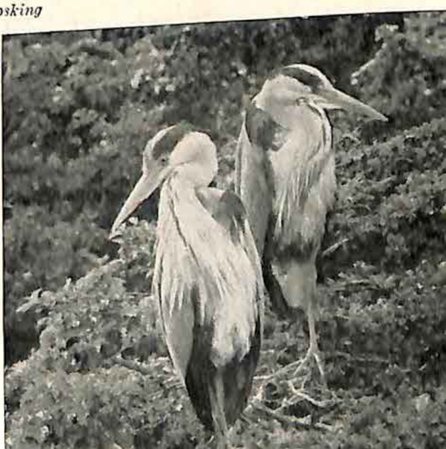
The bill of a hawk is well suited to tearing flesh. That of a woodpecker is chisel-like, and is used to dig insects out of the bark and wood of trees. A heron has a long, spear-like structure, with which it seizes fish and frogs. The bill of the thrush is useful in

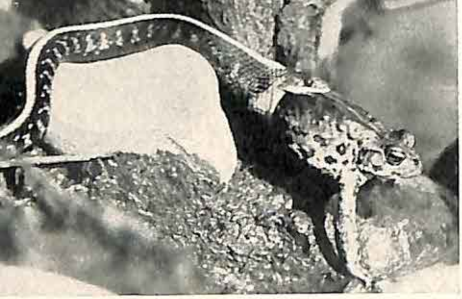
FIGURE 41. A woodpecker.

FIGURE 42. Two young herons.

Eric Hosking

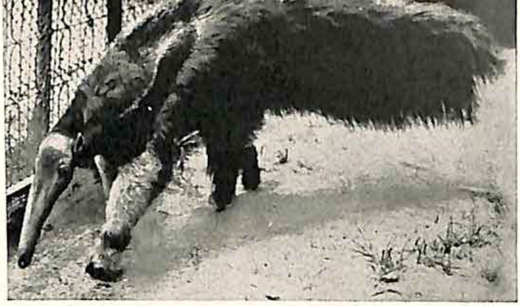






Acme

FIGURE 43. A snake swallowing a frog.



Acme

FIGURE 44. An anteater.

getting worms, insects, and small fruits. Have you ever seen a thrush cracking snail shells on a stone? The large front teeth of a squirrel can be used to cut through the shell of a nut. An anteater thrusts its sticky, long tongue into an ant colony, and the ants stick to it. Snakes are able to swallow their victims entire, even though the latter may be quite large.

Would it be correct to say that most of these animals must have a certain kind of food?

SOME THINGS YOU MAY CARE TO DO

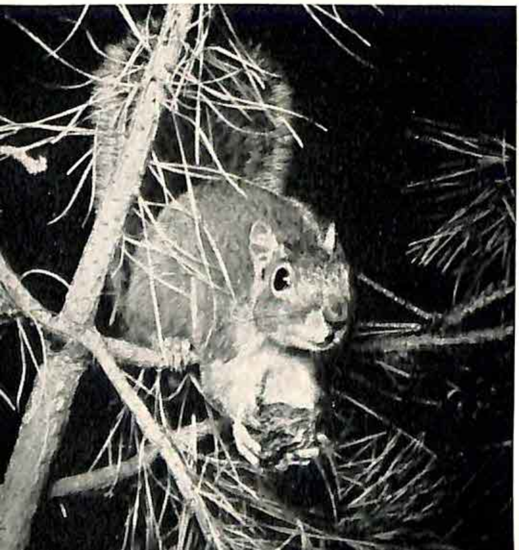
1. Find out what the following animals eat and exactly how they do it: sea anemones, sea lilies, shrimps, woodlice, spiders, millipedes, centipedes, earthworms, leatherjackets, maybugs, herrings, winkles, cockles, mussels, an octopus.

2. Give a report on the most unusual kinds of foods of animals.

3. Give a report on WHALES AND THEIR FOOD. Explain why it is so important for human beings that whales shall not be hunted to extinction.

FIGURE 45. Squirrel eating a nut.

Henry B. Kane



Question 6. **What are Vitamins?**

You now know that the human body needs a number of food substances. They include proteins, carbohydrates, fats, and minerals. This, however, is not all of the story. You recall how sailors in the old days suffered from scurvy. Among other things, their teeth became loose and their gums sore. Then it was found that no scurvy appeared if the men got fresh fruit to eat or the juice of limes to drink.

Vitamin C. What protected the sailors ? We now know that the answer is a *vitamin* ; in this case, Vitamin C. It is really present in only small quantity, when compared with other things, but it is a substance that the body must have. Fresh vegetables and fresh meat also contain Vitamin C.

We have also learned that there are other vitamins—all of greater or lesser importance to us. Study Figure 46 on page 61. Do you commonly eat all these foods ? What can happen when not enough vitamins are present in foods that we eat ? You may find pictures that indicate the improvement that is shown when the right vitamins are added to the diet.

Do you see one reason why a person may be well fed, but poorly nourished ?

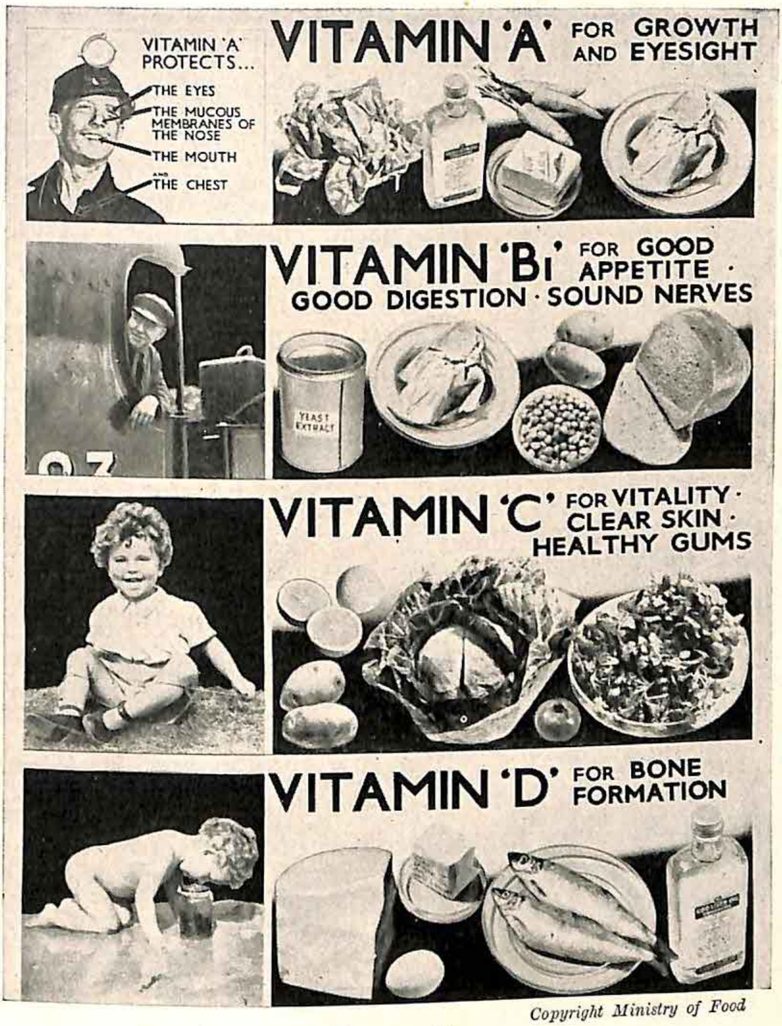
THE VITAMINS

Vitamin A. Among the well-known vitamins are A, B, C, and D. Each of these is present in a number of foods. Actually, only a very small amount may be there, but what a difference this makes ! Vitamin A is well represented in carrots, butter, egg yolks, cod, halibut and shark livers, and leafy vegetables. When the body lacks this substance, a diseased condition of the skin and eyes is developed. It is thought that there may also be lowered resistance to common colds.

The B Vitamins. Vitamin B is really a collection of several things, some of which are now referred to as B_1, B_2, and so on. Foods that contain rather large amounts of Vitamin B are rice husks, wheat, other cereals, liver, milk, and eggs. Scientists got on the trail of the subject by studying the Oriental disease beri-beri. This disease of the nervous system was found to develop when people lived largely upon a diet of polished rice (rice from which the husks had been removed). The necessary vitamin was in the husks, but not in the white rice grains. Vitamin B_1 has been used successfully in treating certain ailments of the nervous system.

Vitamin D. Vitamin D is found in egg yolks, fish-liver oils, coconut oil, and milk. It can also be supplied to some foods by placing them in a special light called ultra-violet. Children with a certain blood condition who do not get enough Vitamin D, or sunlight, may develop what is known as *rickets*. This state results from the fact that the body cannot use minerals in a normal way, and that the bones fail to harden as they should. Enough Vitamin D in the diet will tend to prevent rickets.

Most people probably do not need to worry about vitamins, provided they follow their doctor's advice and eat a variety of the protective foods. One of these is milk, which is remarkable because it appears to contain most of the vitamins. Other protective foods include fresh fruits, vegetables, eggs, meat, and fish. In general, it probably is a good idea to eat a variety of different foods so that if one of them fails to supply


VITAMIN 'A' PROTECTS...
THE EYES
THE MUCOUS MEMBRANES OF THE NOSE
THE MOUTH
AND THE CHEST
VITAMIN 'A' FOR GROWTH AND EYESIGHT
VITAMIN 'B1' FOR GOOD APPETITE · GOOD DIGESTION · SOUND NERVES
YEAST EXTRACT
VITAMIN 'C' FOR VITALITY · CLEAR SKIN · HEALTHY GUMS
VITAMIN 'D' FOR BONE FORMATION

Copyright Ministry of Food

FIGURE 46.

what is needed, another may. People are not all alike —some need more of one vitamin than of another.

Recently so much has been found out about vitamins that the whole subject has become very complicated. For instance, we now know that many people, but not all, can manufacture some of their own B_1 vitamins by the action of bacteria in their large intestine. We also know that not all animals need Vitamins A and D—probably only the animals with a backbone. And we know that all animals, except guinea pigs and some apes and the human race, are able to manufacture their own Vitamin C.

Most of our vitamins come originally from plants: we now know that at least some of the vitamins made by plants are as essential to them as they are to us.

SOME THINGS YOU MAY CARE TO DO

1. After looking up a book on vitamins prepare a report on pellagra—its causes, and how it can be prevented or cured.
2. After getting help from your librarian, report upon some of the things being done with Vitamin B_1 in the business of raising plants. Find out if any of the B vitamins can now be made in the laboratory.
3. Prepare a chart which lists (*a*) the vitamins, (*b*) the diseases or conditions that result from their absence in the diet, and (*c*) the foods which contain them.
4. Collect and exhibit various substances, such as vitamin tablets, and capsules containing vitamin oils. Compare the cost and vitamin content of these items.
5. Write to F.A.O. (see p. 44) and World Health Organisation, Geneva, for information on supplying vitamins to underfed peoples.

REVIEW QUESTIONS

1. What are some of the things that both plants and animals can do?
2. What is meant by a *cell*? What does a cell contain?
3. What things can *protoplasm* do?
4. Are all plants and animals of the same kind exactly alike?
5. How do *adaptations* help survival?
6. Why do leaves change colour in the autumn?
7. In what four ways can plants survive in unfavourable weather?

8. Are there any plants without chlorophyll ? If so, how do they get their nourishment ?

9. Could it be true that most living things consist mainly of water ?

10. Is it true to say that bananas can be grown in England ?

11. What is meant by a pond community ? Why must many of the small creatures that live there find it a very dangerous community in which to live ?

12. What are more scientific terms than " cold-blooded " and " warm-blooded " animals ?

13. What is meant by *hibernation* ?

14. Why is dark clothing likely to be uncomfortable in summer ?

15. What is meant by *insulation* and why is it important ?

16. How is air used by man to provide comfortable living conditions ?

17. What materials are used by a green plant in making foods ? What supplies the energy for this process ?

18. Name some animals that eat plants. Name some plants that eat animals. Now name some animals that eat animals that eat plants.

19. How are the mouth parts of animals related to the type of food they eat ?

20. What food substance or what kind of food is most important for purposes of developing and repairing cells ?

21. Why do young animals require more *protein* in their food than old animals ?

22. Why do you think eggs are rich in protein ?

23. Can you guess why it is that only the female mosquito sucks blood ?

24. In what ways are vitamins important to us ? What diseases are likely to develop from deficiency of vitamins in the diet ?

CAN YOU SELECT THE BEST CONCLUSION ?

Write down the phrase in italics which is the best answer to each question.

1. Do very small plants seem (*a*) *very much like* or (*b*) *very different from* very small animals ?
2. Are single-celled animals (*a*) *the simplest kinds of animals*, (*b*) *animals that contain chlorophyll*, or (*c*) *animals that make food from carbon dioxide and water* ?

3. Are single-celled plants (*a*) *about the size of a pinhead*, (*b*) *about one inch in diameter*, or (*c*) *too small to be seen with the unaided eye* ?
4. Are fungi (*a*) *plants that contain chlorophyll*, (*b*) *single-celled animals*, or (*c*) *dependent plants* ?
5. Is chlorophyll (*a*) *the substance that makes plant cells green*, (*b*) *a kind of one-celled plant*, or (*c*) *pond scum* ?
6. Are plants and animals similar in some ways because (*a*) *the living substance in their cells is similar*, (*b*) *the chlorophyll in their cells is the same*, or (*c*) *the cells of which they are made are the same size and shape* ?
7. Is the living substance in cells called (*a*) *protoplasm*, (*b*) *chlorophyll*, or (*c*) *the cell wall* ?
8. Can plants make food without (*a*) *sunlight*, (*b*) *chlorophyll*, or (*c*) *salts* ?
9. Do plants get carbon dioxide from (*a*) *the air*, (*b*) *sunlight*, or (*c*) *soil water* ?
10. Do animals (*a*) *make food from carbon dioxide and water*, (*b*) *make food from oxygen, nitrogen, and carbon*, or (*c*) *eat foods already made* ?
11. Do cattle and horses eat (*a*) *only plants*, (*b*) *only other animals*, or (*c*) *both plants and flesh* ?
12. Does the food of lions and tigers consist of (*a*) *plants*, (*b*) *flesh*, or (*c*) *plants and animals* ?
13. Do human beings eat (*a*) *few*, (*b*) *a great many*, or (*c*) *no* green plants directly ?
14. Do human beings raise (*a*) *some*, (*b*) *all*, or (*c*) *none* of the foods they eat ?
15. Are the food habits of people (*a*) *exactly the same*, (*b*) *almost the same*, or (*c*) *quite different* in different parts of the world ?
16. Are lean meats composed largely of (*a*) *fats*, (*b*) *carbohydrates*, or (*c*) *proteins* ?
17. Are new cells formed chiefly from the (*a*) *carbohydrates*, (*b*) *proteins*, or (*c*) *fats* in foods ?
18. Does the energy supply of the body come chiefly from the (*a*) *carbohydrates and fats*, (*b*) *proteins*, (*c*) *vitamins and minerals* in foods ?
19. Do the cells get the energy they need from the (*a*) *slow burning of the cell materials*, (*b*) *rapid oxidation of carbon*, or (*c*) *rapid burning of foods* ?
20. Do plants make use of (*a*) *both oxygen and carbon*, (*b*) *oxygen but not carbon*, (*c*) *carbon but not oxygen* ?
21. Do animals use the (*a*) *oxygen*, or (*b*) *carbon* set free by green plants ?
22. Do green plants use the (*a*) *oxygen*, or (*b*) *carbon dioxide* set free by animals ?